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CROP TESTS AT THE COOPERATIVE TESTING STATION, SACATON, ARIZ.

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HISTORY OF THE INVESTIGATIONS.

The Cooperative Testing Station located at Sacaton, Ariz., on the Gila River Indian Reservation, was established in 1907 through a cooperative arrangement between the Office of Indian Affairs of the United States Department of the Interior and the Bureau of Plant Industry of the United States Department of Agriculture. The station was created for the study of agricultural problems of the Southwestern States with special reference to those which might have possibilities of value for the Indians on the Gila River Reservation. Most of the inhabitants of the reservation belong to the Pima tribe, though there are a few settlements of Maricopa and Papago people.

The experimental work of the station has also been conducted as a cooperation between different Offices of the Bureau of Plant Industry, especially the Office of Crop Physiology and Breeding Investigations in cooperation with the Office of Crop Acclimatization and Adaptation Investigations and the Office of Alkali and Drought Resistant Plant Investigations. Though many other crops have received attention, the principal lines of experimental work at the station have related to the breeding and cultural improvement of Egyptian cotton and the development of the cotton industry in Arizona which has occurred since the station was established.

During the period from 1908 to 1916, E. W. Hudson was superintendent of the station, and it was largely through his efforts that the growing of Egyptian cotton in the Salt River Valley became recognized as a practicable industry. S. H. Hastings was superintendent of the station from 1916 to 1920 and had much to do with solving some of the cultural problems in relation to Egyptian cotton.

In 1917 a seed farm was established to provide adequate supplies of pure seed of the new and improved varieties originated or developed at the Cooperative Testing Station, for distribution to the Indians of the reservation.

From the beginning of its history much of the work of the station has related to the breeding, improvement, and culture of Egyptian cotton and the development of the Egyptian cotton industry in Arizona, which became recognized as a practical possibility as a result of the early years of the station work.

In 1912, after four years of field tests at the station had shown that the Yuma variety of Egyptian cotton was suitable for commercial production, seed was placed in the hands of a small group of farmers in the Salt River Valley, Ariz., and with it the Egyptian cotton industry in the Southwest had its beginning.

The Pima variety (fig. 1) had its origin in 1910, when it was selected as a single plant out of a field of Yuma cotton that was being grown at the station. This variety was not grown commercially until 1916, after five years of field tests at the station had demonstrated that it was decidedly superior in many respects to the Yuma variety. Seed was then distributed to a group of farmers in the Salt River Valley, and the growing of the Yuma variety was definitely discontinued as the increasing supplies of Pima seed became available. Since that time Pima has been grown to the exclusion of all other varieties in the Salt River Valley. Beginning in 1916 with 275 acres in the Salt River Valley, the area planted to this variety in 1920 had increased to 180,000 acres, but was reduced to 70,000 in 1921. Over 2,600 acres were planted to Pima cotton in the season of 1920 by the Indians on the Gila River Reservation.

During its history the Cooperative Testing Station has been responsible for the development and improvement of other varieties of economic plants. After several years of careful selection a strain of White Bermuda onions has been developed, called "Sacaton Bermuda." This selection is superior in many ways to the original Bermuda type and possesses certain advantages in the local market.

A strain of Laguna corn called "Sacaton June" has been established by selection and has proved superior in many ways to the original strain for local production.

The first demonstration that pecans could be grown successfully in the valleys of southern Arizona was made at the station from plantings begun in 1908.

The purpose of this report is to present some of the unpublished data on crop experiments conducted at the station since its establishment, to list some of the varieties of crop plants that have proved best adapted for local production, and to record the progress of some of the investigations that are being conducted at the present time.

In some instances experiments started were interrupted and data on other experiments were not obtainable, but in all cases in this report the data are presented as far as available.

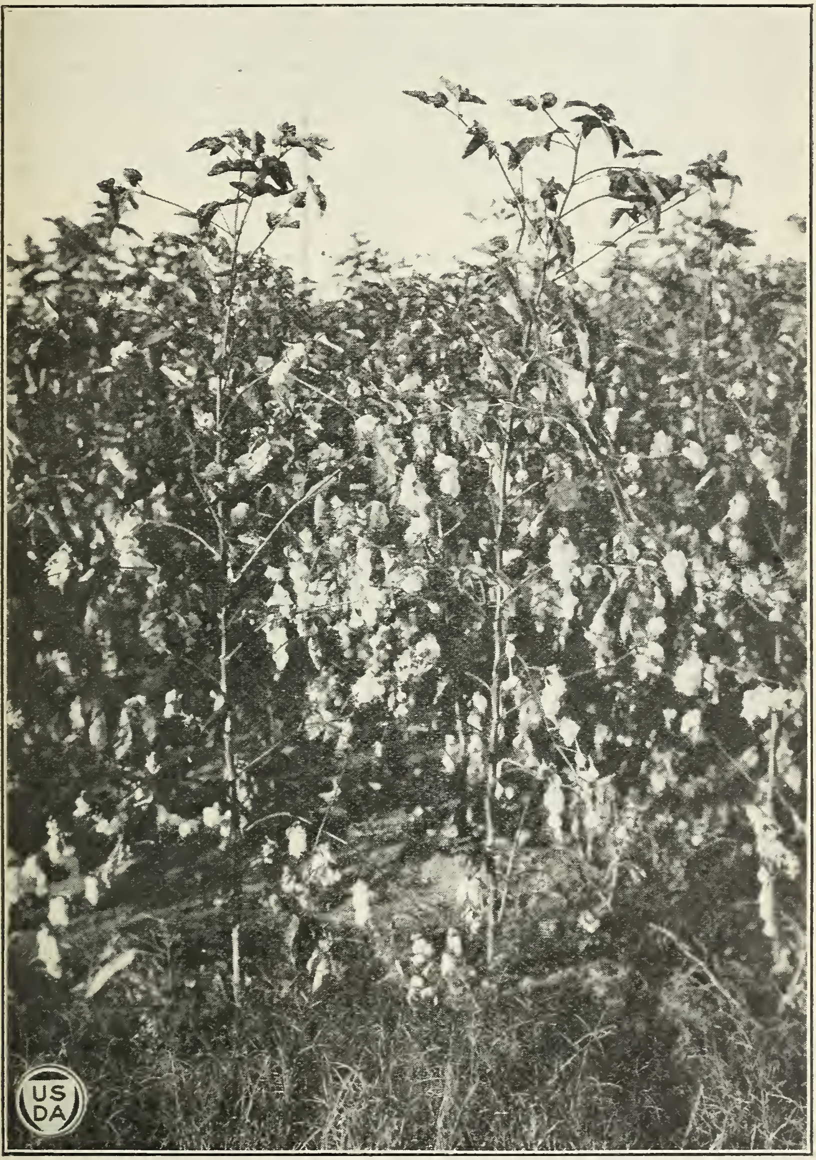

FIG. 1.—Type of Pima Egyptian cotton plant developed at the Cooperative Testing Station, Sacaton, Ariz.

In order to show the nature of some of the problems being dealt with in recent years the scope of the work at the station and seed farm in 1921 is given here.

SCOPE OF THE WORK IN 1921.

The work of the Cooperative Testing Station in 1921 consisted mainly of field experiments with cotton, designed to test the various methods of culture, including spacing, time of thinning, time of planting, and the furrow-bed method. Numerous irrigation experiments were made with cotton for the purpose of ascertaining the optimum quantities and the proper frequencies of applying irrigation water. A comprehensive test of cotton varieties has been made, special attention being given to those upland varieties which are grown extensively in the neighboring valleys of the Southwest and to the comparative behavior of the upland and Egyptian types of cotton. All breeding and selection studies in cotton were made in cooperation with the Office of Alkali and Drought Resistant Investigations of the Bureau of Plant Industry.

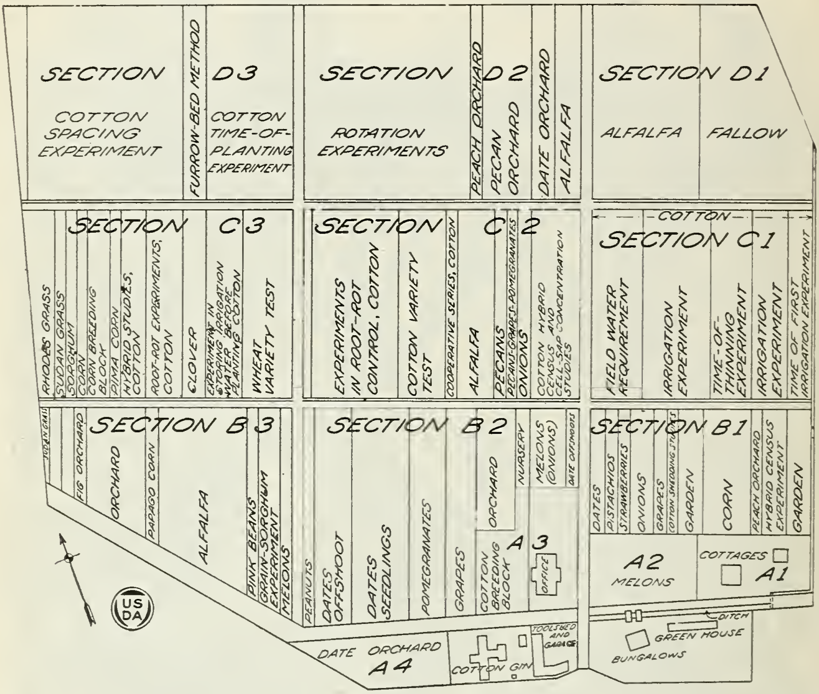

FIG. 2.—Diagram of the Cooperative Testing Station, Sacaton, Ariz., showing the arrangement of the fields and the location of the experiments in 1921.

In testing wheat and barley varieties, the Office of Cereal Investigations cooperated. The Office of Biophysical Investigations cooperated in corn-breeding and corn-variety tests and in securing meteorological data. The Office of Crop Physiology and Breeding Investigations cooperated in the horticultural experiments, special attention being given to the rooting of date offshoots and to the testing of varieties of dates, grapes, nuts, deciduous fruits, and hardy citrus stocks.

A 2-year system of crop rotation inaugurated in 1919 but interrupted in 1920 was reestablished in 1921. From this experiment it is expected to obtain data which will show what crops are most profitable for growing in alternation with cotton and the relation of such practice to the yield of the different crops. Detailed investigations were made as to the manner of spread of the cotton root-rot fungus, and experiments were conducted in attempting to control the disease. In cooperation with the State Agricultural Experiment Station, a fertilizer experiment was conducted in 1921 at the seed farm in order to ascertain if there was any response of cotton to organic and mineral plant foods on dry sandy mesa soils representative of large areas of land in the middle Gila Valley.

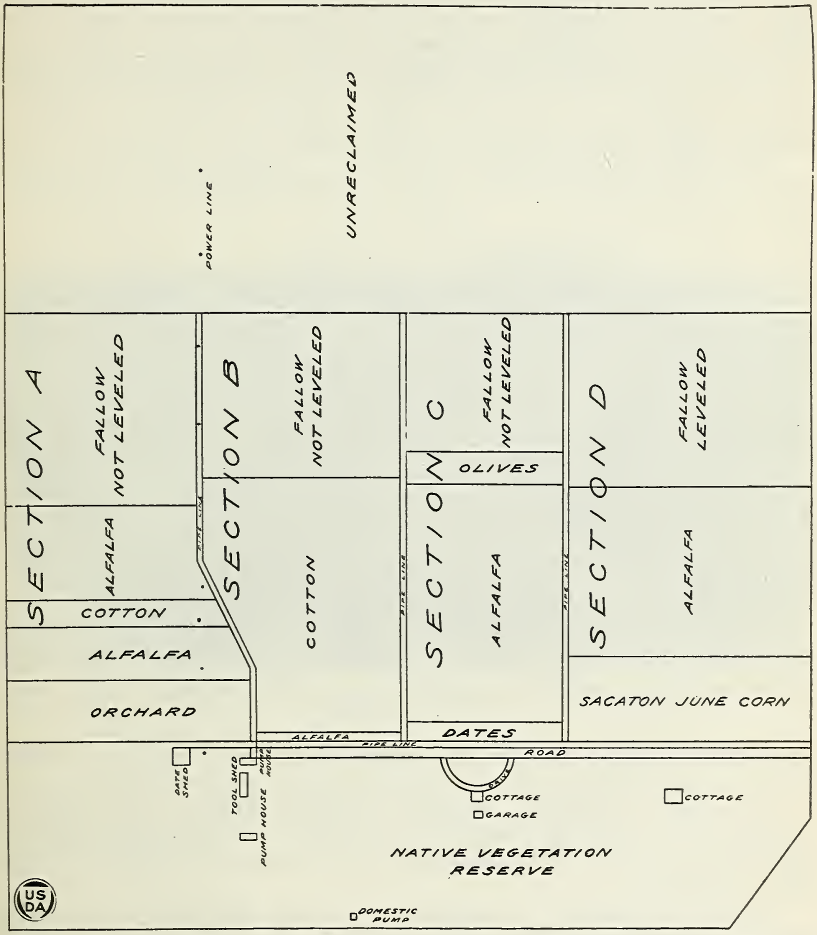

FIG. 3.—Diagram of the seed farm, Sacaton, Ariz., showing the arrangement of the fields and the location of the buildings and experiments in 1921.

Diagrams showing the location of buildings and the arrangement of crop experiments at the station and seed farm in 1921 are shown in Figures 2 and 3.

CLIMATIC AND SOIL CONDITIONS.

The climatic conditions at Sacaton are not greatly different from those that obtain in the Salt River Valley, Ariz. The region is characterized by mild and sunny winters, hot summers, pleasant springs and autumns, and light rains. Hail, high winds, and destructive storms occur but rarely. The characteristic feature is the great daily range in temperature, which at Sacaton reaches an average of 35° F. Daytime temperatures often exceeding 100° F. but rarely higher than 108° F. prevail from about June 15 to September 1 at Sacaton, but owing to the small amount of atmospheric humidity, cooling is rapid at night, so that living conditions are not unpleasant. There are, however, occasional sultry periods during the summer months when the increased humidity with high temperatures make conditions less pleasant for the inhabitants, and also less favorable to the normal fruiting of crop plants such as cotton.

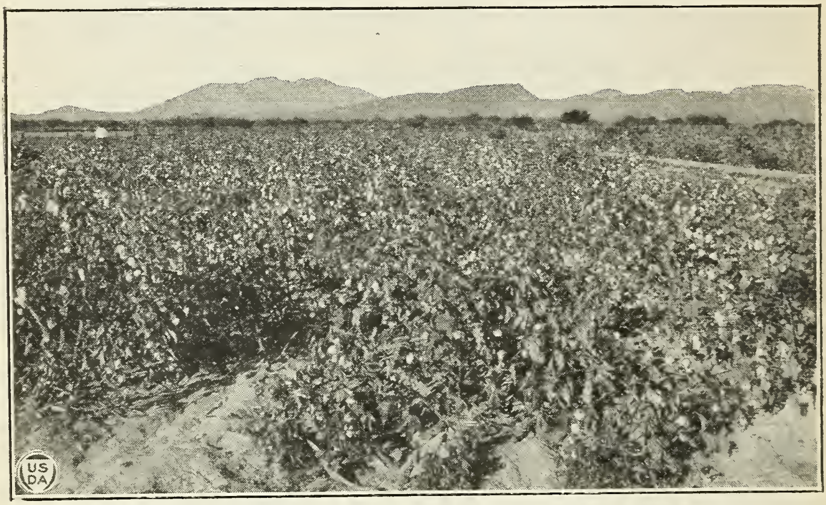

FIG. 4.—Field of Pima cotton on soil of the Pima sand type at the Cooperative Testing Station, Sacaton, Ariz.

The annual rainfall at Sacaton averages slightly more than 10 inches, with a correspondingly low humidity. The greatest amount of rainfall occurs in July and the least during the months of April, May, and June.

The growing season at Sacaton is considerably shorter than that of the greater part of the Salt and Gila River Valleys. The station being located on the banks of the Gila River, at a lower elevation than the surrounding foothills and mesas, is less favored in respect to atmospheric drainage, and killing frosts are likely to occur earlier in the fall and later in the spring than in more favored localities, such as the seed farm and the greater part of the cultivated area in the Salt River Valley. The average length of the season free from killing frosts at the station is 263 days; at Tucson, Ariz, 254 days; and at Phoenix, Ariz., 289 days. While not adapted for citrus or the less hardy vegetables and flowering plants, the growing season is usually of sufficient length for the successful growth and maturity of Egyptian cotton, certain date varieties, olives, pomegranates, and other subtropical plants. The meteorological data for the past 12 years are summarized in Table 1 from observations made at the station.

The soil at the station is an alluvial deposit composed largely of fine sands and silt. It has been classified by the Bureau of Soils as Pima sand and is representative of considerable areas extending in narrow strips along the Gila River, which when not impregnated with alkali are well adapted for general farming. (Fig. 4.) The considerable quantity of silt in its composition gives this soil a large water-holding capacity and is largely responsible for its exceptional fertility even when in virgin condition.

TABLE 1.—*Summary of meteorological observations at the Cooperative Testing Station, Sacaton, Ariz., with comparative data in regard to killing frosts at Phoenix, Ariz., for the 12-year period from 1910 to 1921, inclusive.*

RAINFALL (INCHES).

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1910	0.75	0	0.50	0	0	0	0.65	1.45	0	0	2.36	0.31	6.02
1911	1.52	.69	.47	0	0	0	.11	.82	1.38	1.40	0	.25	6.64
1912	0	0	2.61	.85	.38	.98	4.27	1.02	0	.96	0	1.05	12.12
1913	.72	.72	0	.40	0	.07	.92	.73	.04	.18	2.63	.81	7.22
1914	.18	.39	1.02	.16	.10	.34	3.26	1.77	.30	2.28	1.79	5.16	16.75
1915	2.45	1.45	1.01	1.16	.69	.10	2.44	1.05	0	0	.44	3.85	14.64
1916	2.87	.26	.71	.45	0	0	1.19	.63	3.61	.02	0	.65	10.39
1917	1.47	.67	.40	.11	1.29	0	3.33	.05	.43	.16	0	0	7.91
1918	1.15	.77	1.17	.19	0	.20	1.09	1.63	.47	.29	.88	2.07	9.91
1919	.01	1.47	.55	.20	.04	0	3.76	1.63	1.80	.15	2.48	.89	12.98
1920	2.03	.98	1.41	.03	.17	.23	.48	.89	.21	1.21	0	0	7.64
1921	.44	.34	.09	.08	.09	0	2.41	3.26	.39	.23	.11	.80	8.24
Average	1.13	.65	.83	.30	.23	.17	1.99	1.24	.72	.57	.89	1.32	10.04

EVAPORATION (INCHES).

1917	......	......	......	......	......	......	......	4.480	6.305	4.803	3.082	2.474	21.144
1918	2.449	2.558	3.937	6.708	8.091	8.401	7.440	7.037	6.660	4.800	2.907	2.196	63.184
1919	2.496	2.051	4.230	5.770	7.564.	8.767	7.247	6.209	5.918	3.139	2.668	1.820	57.879
1920	1.768	2.095	3.794	4.533	7.440	7.297	8.094	7.576	6.035	3.233	3.104	3.143	58.112
1921	2.283	3.503	5.782	6.845	8.791	8.402	7.265	6.520	6.019	4.827	2.898	2.105	65.240
Average	2.249	2.552	4.436	5.964	7.972	8.217	7.512	6.364	6.187	4.160	2.932	2.348	53.112

DAILY WIND VELOCITY (MILES PER HOUR).

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maximum:												
1917	......	......	......	......	......	......	......	......	4.6	3.9	3.6	3.3
1918	4.4	5.1	5.4	5.0	7.0	3.8	4.1	3.0	5.0	2.9	4.0	4.0
1919	7.6	7.1	6.3	4.4	3.6	3.5	2.2	2.4	6.0	2.5	5.0	3.3
1920	4.2	2.3	4.2	7.6	2.9	3.8	3.1	2.7	4.0	4.0	2.5	5.0
1921	3.5	5.7	4.6	5.5	5.4	2.3	4.9	2.3	1.9	4.4	2.4	3.6
Minimum:												
1917	......	......	......	......	......	......	......	......	.8	.4	1.1	1.0
1918	1.2	.5	.6	1.1	.3	.5	.2	.5	.4	.8	1.1	.8
1919	.7	.3	1.1	1.3	.9	.7	.4	.5	.5	.7	.6	.5
1920	.9	.9	.4	.5	.1	.2	.1	.9	.3	.5	.4	.8
1921	1.1	1.3	1.3	1.0	1.4	1.1	.3	.1	.6	.7	.8	.9
Average:												
1917	......	......	......	......	......	......	......	......	1.8	1.5	1.6	1.4
1918	1.9	2.3	2.1	2.8	3.0	1.9	1.9	1.5	1.9	1.7	2.1	2.1
1919	2.8	2.9	2.7	2.2	1.9	1.7	1.3	1.2	1.7	1.3	1.8	1.6
1920	1.9	1.6	1.5	2.1	1.5	1.6	1.1	1.7	1.6	1.7	2.0	1.9
1921	1.8	2.3	2.3	2.7	2.4	1.6	1.6	1.0	1.1	1.3	1.2	1.6

TABLE 1.—*Summary of meteorological observations at the Cooperative Testing Station, Sacaton, Ariz., with comparative data in regard to killing frosts at Phoenix, Ariz., for the 12-year period from 1910 to 1921, inclusive*—Continued.

TEMPERATURE, °F.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Absolute maximum:												
1910	81	84	98	106	117	114	115	110	111	107	92	82
1911	81	80	92	95	101	109	109	109	108	96	88	86
1912	84	84	84	92	107	112	110	113	104	96	90	73
1913	73	80	90	98	103	108	112	110	108	100	89	76
1914	79	88	96	100	109	114	113	114	108	96	95	75
1915	75	80	88	97	107	111	113	113	108	105	98	79
1916	75	86	98	101	105	114	113	110	108	92	94	88
1917	79	79	90	93	102	112	111	103	104	102	90	80
1918	82	80	84	92	96	111	106	111	104	99	91	78
1919	74	77	84	97	98	110	106	109	103	89	83	75
1920	81	75	82	92	101	108	111	105	103	99	82	78
1921	80	92.5	93	97.5	101	110	107	106	103	99	88	79
Absolute minimum:												
1910	17	17	32	39	44	56	62	65	55	40	33	24
1911	18	24	37	35	43	52	57	61	54	36	19	17
1912	17	25	35	36	42	54	56	65	49	33	31	20
1913	9	29	27	36	39	48	61	61	43	37	38	28
1914	25	27	33	42	44	56	68	67	60	47	35	21
1915	23	30	30	41	33	51	58	65	48	43	22	24
1916	27	24	33	35	44	54	62	63	55	37	21	15
1917	28	27	25	35	42	44	69	59	48	33	31	23
1918	20	27	34	38	46	52	66	58	53	30	25	26
1919	20	28	28	40	52	45	69	62	56	36	27	29
1920	27	33	31	37	43	53	58	58	48	35	20	21
1921	20	24.5	30	31	42	48	58	68	55	30	21	22
Mean:												
1910	51.5	52.7	63.5	70.2	78.1	85.2	89.2	89.7	85.8	72.0	60.0	53.9
1911	54.3	52.6	64.0	67.5	73.3	83.9	86.1	86.3	82.3	69.2	56.6	45.6
1912	51.4	54.8	58.3	62.1	73.7	85.5	85.6	85.6	78.3	68.2	58.6	47.5
1913	45.8	52.5	56.1	67.2	74.1	81.9	87.0	88.8	82.6	69.5	61.7	50.3
1914	54.6	54.5	62.5	68.9	76.3	85.2	88.8	88.4	84.3	69.4	63.1	50.7
1915	52.0	55.7	57.2	66.8	70.6	83.9	88.9	89.0	81.6	72.7	59.0	50.2
1916	51.9	59.1	64.9	69.0	74.1	84.5	89.5	88.2	83.0	67.7	56.9	48.7
1917	50.1	52.9	55.3	64.1	68.6	83.1	89.3	84.6	81.8	72.0	60.7	51.7
1918	49.5	54.5	61.3	65.1	70.3	86.3	86.6	83.1	81.5	69.8	55.5	48.7
1919	48.1	50.2	54.3	66.1	73.8	81.9	85.9	86.0	79.8	65.2	56.4	51.9
1920	51.1	56.0	57.5	61.4	72.1	79.7	87.6	89.6	78.4	66.1	56.3	46.9
1921	49.9	55.1	62.7	62.9	71.3	82.5	86.4	84.3	80.1	71.4	58.4	54.2
Average	50.8	54.2	59.8	65.9	73.0	83.6	87.6	87.0	81.6	69.4	58.6	50.0
Mean maximum:												
1910	69.0	72.4	87.3	89.9	98.9	104.9	106.1	104.6	103.4	91.3	77.4	72.1
1911	68.8	66.4	81.3	86.2	94.0	103.2	99.6	102.8	98.7	85.8	75.9	63.4
1912	71.8	75.4	72.2	77.9	92.2	104.1	101.4	100.2	97.7	84.4	77.6	63.2
1913	62.0	66.6	73.5	85.1	93.8	100.9	103.2	104.2	100.9	90.2	75.1	64.8
1914	69.7	72.1	80.7	87.0	96.2	102.5	103.1	104.1	100.2	84.9	80.6	62.6
1915	66.8	73.2	75.2	84.4	89.2	104.1	105.1	106.0	100.5	95.5	78.6	66.8
1916	62.9	76.6	84.2	87.4	95.5	105.9	105.7	103.4	99.7	86.2	79.0	68.7
1917	63.6	69.1	73.7	81.6	86.7	103.6	102.0	99.9	95.7	91.3	80.2	72.7
1918	64.6	69.6	75.1	82.4	87.5	101.9	100.1	97.1	97.9	87.2	71.5	61.4
1919	64.2	64.5	70.5	83.9	90.4	100.6	97.7	99.5	93.2	80.7	72.7	68.0
1920	64.2	68.4	73.8	78.3	90.9	98.9	104.5	99.1	95.4	83.5	74.6	66.2
1921	67.2	73.3	80.1	81.9	89.6	100.9	98.6	96.4	96.3	89.9	78.3	68.7
Average	66.2	70.6	77.3	83.8	92.1	102.7	102.3	101.4	98.3	87.6	76.8	66.6
Mean minimum:												
1910	33.1	32.4	39.7	50.5	57.3	65.4	72.2	74.8	68.1	52.6	42.5	35.7
1911	39.7	38.8	46.7	48.7	52.6	64.6	72.5	69.8	65.8	52.6	37.2	27.7
1912	31.0	34.1	44.3	46.3	55.1	66.9	69.7	70.9	58.9	51.9	39.5	31.8
1913	29.6	38.3	38.7	49.3	54.3	62.8	70.7	73.3	64.2	48.8	48.2	35.7
1914	39.4	36.9	44.3	50.7	56.4	67.8	74.5	72.6	68.4	53.9	45.6	38.8
1915	35.1	38.2	39.2	49.1	51.9	63.7	72.6	71.9	62.6	49.8	38.3	33.6
1916	40.9	41.6	45.5	50.6	52.6	63.1	73.3	72.9	66.2	49.1	34.7	28.7
1917	36.5	35.3	36.7	46.6	52.3	62.5	76.2	69.2	68.0	52.6	41.1	30.7
1918	32.4	38.4	47.5	47.6	52.7	70.6	73.2	69.2	65.1	52.4	39.4	36.9
1919	31.9	35.8	38.4	48.5	57.2	63.2	74.1	72.4	66.9	49.7	40.1	35.9
1920	37.9	43.5	41.2	44.5	53.2	60.4	70.7	70.1	61.3	48.6	38.0	27.6
1921	32.5	36.8	45.2	43.9	53.0	64.0	74.2	72.2	63.8	52.9	38.5	39.7
Average	35.0	37.5	42.3	48.0	54.1	64.6	72.7	71.6	64.9	51.2	40.3	33.6

TABLE 1.—*Summary of meteorological observations at the Cooperative Testing Station, Sacaton, Ariz., with comparative data in regard to killing frosts at Phoenix, Ariz., for the 12-year period from 1910 to 1921, inclusive*—Continued.

KILLING FROSTS.

Year.	At Sacaton.			At Phoenix.[1]		
	Last in spring.	First in autumn.	Frost-free period (days).	Last in spring.	First in autumn.	Frost-free period (days).
1910	Feb. 28	Dec. 6	280	Feb. 18	Dec. 23	308
1911	Feb. 17	Nov. 12	267	Feb. 17	Nov. 26	282
1912	Feb. 27	Nov. 13	259	Jan. 29	Dec. 19	325
1913	Mar. 27	Dec. 2	249	Mar. 1	Dec. 5	279
1914	Feb. 27	Dec. 7	282	Feb. 7	Dec. 8	304
1915	Mar. 7	Nov. 11	248	Mar. 3	Nov. 13	255
1916	Feb. 3	Nov. 8	278	Feb. 2	...do....	285
1917	Mar. 23	Nov. 30	251	Mar. 4	Dec. 8	279
1918	Feb. 20	Oct. 27	248	Feb. 20	Nov. 8	260
1919	Mar. 6	Nov. 1	239	Mar. 1	Nov. 29	272
1920	Jan. 12	Nov. 10	302	Jan. 12	Dec. 13	336
1921	Feb. 16	Oct. 28	254	Feb. 8	Nov. 19	283
Average	Feb. 25	Nov. 15	263	Feb. 14	Nov. 30	289

[1] Data from the United States Weather Bureau.

The soil at the seed farm is a sandy loam formed from the weathering of the adjacent mountains. It is of uniform texture to a considerable depth. The particles range in size from fine sand to gravel, the medium sands predominating. This soil, when first cleared of its native vegetation (*Covillea glutinosa*), is deficient in available plant food, and the low water-holding capacity restricts the effectiveness of irrigation. However, it lends itself very readily to methods of improvement, such as growing cover crops, and when once alfalfa is well established the fertility problem is solved. Even in its virgin state this type of soil seems well adapted to the growing of many tree crops, especially some of the deciduous fruits. It is representative of large areas of foothill lands in the middle Gila or Casa Grande Valley.

COTTON.

COTTON VARIETY TESTS.

For a number of years tests have been made at Sacaton with the best-known varieties of upland cotton which are grown in Texas and the southeastern cotton-growing States, to determine their adaptability to the arid conditions of the Southwest. Included with these were varieties from Mexico and Central America recently introduced by the Department of Agriculture with the design of developing varieties better adapted for production under boll-weevil conditions. In these tests the plant behavior of the varieties was studied, but no large plantings were made for yield tests until 1920. The recurrent agitation on the part of a few farmers to grow upland varieties in the Salt River Valley made it seem advisable to obtain definite information in regard to the merits of the two types, upland and Egyptian, under the prevailing climatic conditions. In 1920 two upland varieties, Durango and Lone Star, were planted in comparison with Pima on one-fourth acre plats. This experiment was continued in 1921 with the addition of Acala, a variety which is grown extensively in northern Texas, in Oklahoma, and in the Coachella Valley of California. The results for the two years are given in Table 2.

TABLE 2.—*Yield of seed cotton in variety tests at the Cooperative Testing Station, Sacaton, Ariz., in 1920 and 1921.*

Variety.	Yield per acre (pounds).		Variety.	Yield per acre (pounds).	
	1920	1921		1920	1921
Pima	1,828	2,196	Lone Star	1,720	1,837
Durango	1,440	769	Acala	....	1,914

Although the opinion appears to be somewhat general throughout the cotton-growing area in Arizona that upland cottons are capable of producing from 50 to 100 per cent more than Egyptian cotton when grown under similar conditions, several years of row comparisons and the yields of plat tests for two years at Sacaton do not justify such a conclusion.

The chief difference in the behavior of the upland varieties and the Pima Egyptian cotton is that the former are capable of setting only a small percentage of the bolls developed from flowers which are produced during the hottest periods of July and August, the greater number being aborted soon after they are formed. The Pima Egyptian variety is not so seriously affected by the severity of the climate and under normal treatment is capable of setting a greater part of its bolls throughout the hottest period of the year.

TIME-OF-PLANTING EXPERIMENTS WITH PIMA COTTON.

Experiments have been carried on since 1917 with the view of helping to solve the farmer's problem of "When is the most desirable date to plant cotton?" These plantings were usually thinned 12 to 14 inches apart in the rows, irrespective of the dates of planting. The later plantings in most cases were not left unthinned as long as the earlier plantings, the higher temperatures causing the later plantings to grow faster in the seedling stage than the earlier plantings. (Table 3.)

It will be observed from Table 3 that the greatest yields were obtained from plantings made during the first half of March, though the difference in yields produced from plantings made during the first, second, and third weeks of March are not considerable. The data indicate that the optimum date for planting at Sacaton occurs during the month of March. Considering the frost data given in Table 1, it would appear that the best time for planting in the Salt River Valley in a normal season should be during the first two weeks of March.

TABLE 3.—*Yields of Pima cotton in time-of-planting tests at the Cooperative Testing Station, Sacaton, Ariz., 1917 to 1921, inclusive.*

[The low yields obtained in 1920 and 1921 can be attributed to the fact that the soil on which the plantings were made has each year become more impregnated with alkali.]

Date planted.	Yield per acre (pounds).				Average.	
	1917	1918	1920	1921	Week of planting.	Yield per acre (pounds).
Feb. 28	1,942				Feb. 21 to Mar. 1	1,942
Mar. 4		2,512			Mar. 1 to 7	2,235
Mar. 7	2,087	2,105				
Mar. 10				1,140	Mar. 7 to 14	2,219
Mar. 14	2,280	2,158				
Mar. 21	1,931	2,309			Mar. 14 to 21	2,115
Mar. 25				1,263	Mar. 21 to 28	1,722
Mar. 28	2,178					
Apr. 2			1,033		Mar. 28 to Apr. 3	1,606
Apr. 4		2,005			Apr. 3 to 10	1,140
Apr. 5	1,523					
Apr. 9			1,044			
Apr. 10				852	Apr. 10 to 17	1,560
Apr. 11	1,519	1,886				
Apr. 16			1,275			
Apr. 18		1,697			Apr. 17 to 24	1,597
Apr. 19	1,780					
Apr. 23			1,316			
Apr. 25		1,945		292	Apr. 24 to 30	1,292
Apr. 27	1,520					
Apr. 30			1,412			
May 2		1,509			Apr. 30 to May 6	1,507
May 3	2,150					
May 7			862		May 6 to 13	917
May 9		1,413				
May 10	1,204			417		
May 14			634		May 13 to 20	992
May 17	1,350					
May 25				126		
June 10				42		

SPACING EXPERIMENTS.

With the development of the Egyptian cotton industry in Arizona there arose the problem of proper spacing of the plants of this new type of cotton for production of largest yields. Early in the development of the industry a new system of cotton culture was developed by the Department of Agriculture, called the single-stalk system.[1] (Fig. 5.) This system, the cultural idea of which is to suppress the vegetative branches by leaving the young plants close together in the rows and by deferring thinning a little longer than ordinarily practiced, was found admirably adapted to the growing of the Egyptian varieties. Consequently, the principle of this system is generally applied in some degree in every district into which the Egyptian cotton industry has extended, and closer spacing of plants and longer deferred thinnings are practiced in these new areas than in the older cotton-growing districts. Careful study has been given at the station during the years 1918 to 1921 to the problem of proper plant and row spacing, and tests have been made in order to determine as near as possible the optimum space between rows and between plants in the rows. The results for the four years are given in Table 4.

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[1] Cook, O. F. A new system of cotton culture. *In* U. S. Dept. Agr., Bur. Plant Indus. Cir. 115, pp. 15–22. 1913. Bibliographical footnotes.

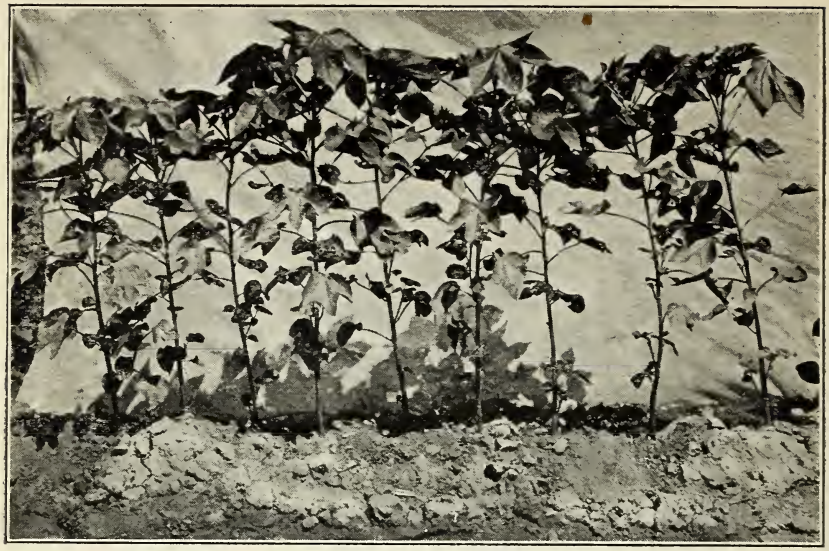

FIG. 5.—Young Pima cotton plants grown under single-stalk culture methods at the Cooperative Testing Station, Sacaton, Ariz.

TABLE 4.—*Yields of cotton in spacing experiments, showing also comparison of rainfall, at Sacaton, Ariz., in 1918 to 1921, inclusive.*

[Yield data in pounds per acre.]

Year.	Spacing distance (inches).					
	Between plants.	Between rows.				
		30	42	54	66	78
1918	4	3,136	2,619	2,612	1,597	1,570
1919		....	1,577	....	....	....
1920		2,113	2,070	1,994	1,606	....
1921		1,148	1,320	1,354	....	....
1918	8	3,009	2,657	2,355	1,907	1,435
1921		1,348	1,391	1,512	....	....
1918	12	2,596	2,315	2,098	1,971	1,383
1920		1,884	1,839	1,826	1,510	....
1921		1,630	1,523	1,570	....	....
1919	14	....	1,878	....	....	....
1918	16	2,462	2,603	1,977	1,784	1,227
1921		1,320	1,258	1,145	....	....
1918	20	1,909	1,729	1,725	1,341	1,565
1918	24	2,058	1,504	1,409	1,324	1,330
1919		....	2,057	....	....	....

PRECIPITATION FOR JUNE, JULY, AND AUGUST.

Month.	1918	1919	1920	1921
June .... inches	0.20	T.	0.23	T.
July .... do	1.09	3.76	.48	2.41
August .... do	1.63	1.63	.89	3.26
Total .... do	2.92	5.39	1.60	5.67

It will be observed from the data in Table 4 that maximum yields can be produced with the plants crowded very close together, provided the quantity of water which the plants are to receive can be well controlled by the grower. It will be seen that during the seasons of 1918 and 1920, when there was insufficient rainfall during the critical growing period to affect the control of plant development, the highest yields of seed cotton were produced where the plants were crowded as close as 30 inches between rows and approximately 4 inches between plants. In the seasons of 1919 and 1921 the unusually heavy rainfall and high atmospheric humidity during the months of July and August caused too rapid growth of the plants. As a result the excessive development of vegetative growth served to produce a canopy over the lower fruiting branches, and with the increased humidity beneath the dense covering of foliage many of the lower fruiting buds and young bolls were aborted and the older bolls were soon rotted. The largest yields of seed cotton for these years were produced by plants with 12-inch spacing between plants in rows 30 inches apart.

IRRIGATION EXPERIMENTS WITH COTTON.

In 1919 an experiment was begun to secure data regarding the proper frequencies for applying irrigation water to cotton and the optimum quantities of water to deliver in each application. For designating the different treatments certain terms were applied which are somewhat arbitrary and have required a revision of meaning in seasons of unusual climatic conditions. The term "normal" was applied to a treatment whereby irrigation water was not applied to the plants in their earlier development until they had attained considerable size and had developed a woody structure. Thereafter irrigations were to be applied with sufficient frequency to prevent any serious check in the production of fruit. The position of the flowers on the plants was used as an index of water needs, irrigation water being applied just before a sufficient number of flowers had appeared in the tops of the plants to give a field a flower-garden effect when glancing over it. The term "heavy" was applied to a treatment whereby the plants were irrigated early and with sufficient frequency thereafter to keep them growing vigorously with no indications of water stress. For the seasons of 1920 and 1921 the irrigation treatment was changed, and no applications of water were made until the plants had reached the flowering stage. After this stage the water was applied at regular intervals as determined by the calendar, the "medium" borders being irrigated about every 15 days and the heavy borders at approximately 10-day intervals.

During the seasons of 1920 and 1921 some intensive studies were made of the individual plant behavior under the different treatments of irrigation. The physiological studies included the obtaining of daily flowering and daily shedding records from representative groups of plants, the weekly growth of main stalk, the time intervals from bud to flower and from flower to open boll, and other data of physiological interest. It was found that the interval from bud to open flower in Pima cotton is 29 to 30 days, while the interval between flower and open boll ranges from about 56 days at the beginning of the flowering season to about 80 days near the end of the season. The total yields per acre obtained from plats under the different treatments are given in Table 5.

TABLE 5.—*Yields of seed cotton under different methods of irrigation at Sacaton, Ariz., in 1919, 1920, and 1921.*

Yield data in pounds per acre. In 1919 the plant spacing was approximately 14 inches. In 1920 and 1921 the spacing was 12 inches.]

Year.	Treatment.	Border.	Yield.	Border.	Yield.	Border.	Yield.	Average yield.
1919	Normal	C1-7	1,666	C1-10	1,984	C1-13	2,017	1,889
1920	do	C1-3	1,961	C1- 9	1,543	C1-12	1,462	1,655
1921	do	C1-3	1,488	C1- 9	1,493	C1-12	1,334	1,438
Average for 3 years								1,661
1919	Medium	C1-8	1,953	C1-11	1,790	C1-14	1,781	1,841
1920	do	C1-4	2,292	C1-10	1,590	C1-13	1,703	1,862
1921	do	C1-4	1,605	C1-10	1,574	C1-13	1,324	1,501
Average for 3 years								1,735
1919	Heavy	C1-9	1,896	C1-12	2,250	C1-15	1,570	1,905
1920	do	C1-5	1,624	C1-11	1,536	C1-14	1,750	1,637
1921	do	C1-5	1,303	C1-11	1,332	C1-14	1,376	1,370
Average for 3 years								1,637

It became apparent early in this investigation that there were factors other than irrigation frequencies influencing the variations in yield. These can be attributed largely to differences in soil fertility and to soil-texture variations in the deeper layers of soil. While no significant differences are shown for any irrigation treatment, it is probable that the medium treatment is the most favorable for the production of large yields in both wet and dry summers.

A test was made in 1921 in order to determine whether there was any advantage in storing large quantities of water in the soil by repeated irrigations before planting cotton. Three one-fourth acre plats were used for this test, plat 1 being irrigated three times prior to planting, plat 2 twice, and plat 3 once. The yields per acre in seed cotton were 1,519, 1,601, and 1,667 pounds, respectively. These yields do not indicate that there was any advantage from irrigating more than once before planting when dealing with soils of this nature.

ROTATION EXPERIMENTS.

An experiment was started in 1919 with the view of securing information as to which of the commonly grown Arizona field crops is best suited for growing alternately with cotton. This experiment was made to include another test which had been in progress for several years with the purpose of determining the effect of continuous cropping of cotton on the same soil. (Fig. 6.) During the past three or four years it has been a much-discussed question in the Salt River Valley whether continuous cropping to cotton would eventually impoverish soils of such a nature as those of the Salt River Valley and make them unproductive. It is hoped that the experiment at the station will prove of some value in this connection in that it has been continued for about 11 years, one half of the area being cropped to cotton without adding to the fertility and the other half receiving a light application of barnyard manure each year. The entire area under this and the rotation experiment was left fallow in 1920 on account of the accumulations of alkali and the invasion of Bermuda grass. The experiments were continued in 1921, however, in their proper order of cropping, and it is hoped that reliable and useful data may yet be obtained. Unfortunately the data of past yields are not obtainable. The results for 1921, however, are given in Table 6.

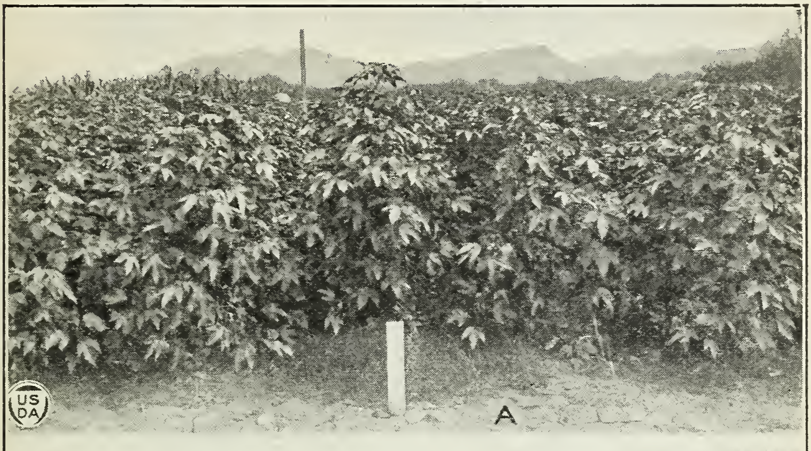

Fig. 6.—Comparison of the behavior of Pima cotton when grown continuously on the same soil and in rotation with alfalfa. In *B* the soil had been cropped to cotton for at least 11 years. In *A* a 2-year cotton-alfalfa rotation had been conducted for several years.

It will be noted that the largest yield of seed cotton was produced on border D2–13 (fig. 6, *A*), which had been cropped in alternate years with alfalfa. The next highest yield was produced on border D2–11, which had been cropped to cotton continuously for at least 11 years, but to which barnyard manure had been applied each year. Next to the smallest yield was produced on border D2–10 (fig. 6, *B*), which had been planted to cotton continuously for at least 11 years with no effort made to increase the fertility.

TABLE 6.—*Yield of crops in the 2-year rotation experiment at the Cooperative Testing Station, Sacaton, Ariz., in 1921.*

Border.	Crop.	Yield.	
		Unit.	Per acre.
D2-10..	Cotton, continuously	Pound	990
D2-11..	Cotton, continuously with manure	..do	1,454
D2-12..	Alfalfa, rotation with cotton	Ton	3.8
D2-13..	Cotton, rotation with alfalfa	Pound	1,676
D2-14..	Corn, rotation with cotton, manured	Bushel	39.7
D2-15..	Cotton, rotation with corn, not manured	Pound	842
D2-16..	Corn, rotation with cotton, not manured	Bushel	56.2
D2-17..	Cotton, rotation with soy beans	Pound	965
D2-18..	Soy beans, rotation with cotton		(1)
D2-19..	Corn, rotation with cotton and soy beans, not manured	Bushel	41.8
D2-20..	Milo, rotation with cotton	..do	34
D2-21..	Cotton, rotation with milo, not manured	Pound	1,103
D2-22..	Sudan grass, rotation with cotton	Ton	4.2
D2-23..	Cotton, rotation with Sudan grass	Pound	1,427

[1] Not harvested.

BARLEY.

Tests have been conducted for two seasons in a comparison of the Mariout, Coast, and Trebi varieties of barley. The results are given in Table 7.

TABLE 7.—*Yields of varieties of barley at the Cooperative Testing Station, Sacaton, Ariz., in 1920 and 1921.*

Variety.	Yield per acre (bushels).		
	1920	1921	Average.
Mariout	80.1	52.9	66.5
Coast	83.3	61.3	72.3
Trebi	75.6	56.7	66.2

There are no outstanding differences at the end of two years of tests that would recommend any one variety above the others for general planting.

CORN.

Corn has long been an important crop of the Indians of southern Arizona, and it was with the hope of improving some of the native southwestern corn varieties by breeding and selection methods that work of this nature was started soon after the establishment of the station. In a few years a strain of the Laguna variety was developed which is called Sacaton June. This variety is generally considered to be the best corn for growing to maturity under Arizona conditions, and some of the seed dealers of the Salt River Valley, to meet the demands of their customers, have been endeavoring to preserve the purity of the commercial stocks of seed.

The Pima Indians who have access to pump water have found the Sacaton June corn well suited to their farming practices, since they are able to raise a crop of corn following the harvesting of their wheat. Some who are dependent upon summer flood water from the Gila River have also been able to produce excellent yields from the Sacaton June variety, but most of those to whom pump water is not available plant some variety of native Indian corn.

The variety called "Pima Soft," or "Pima Squaw," corn is the most popular native variety, in that it meets with favor in some of the markets of the Salt River Valley. It possesses additional value in the fact that it flowers in 50 or 60 days after planting, thereby making small demands on irrigation water. (Fig. 7.) As ordinarily grown by the Indians, this corn rarely yields more than 10 to 15 bushels per acre. Unless flood water is abundant it often happens that the heavy irrigation preliminary to planting is all the water that the crop receives. The Sacaton June variety yields 40 to 50 bushels per acre when given moderate care. This corn is usually planted from June 15 to July 15, while the "Pima Soft" variety is often planted as late as August 1, with ample time for reaching maturity.

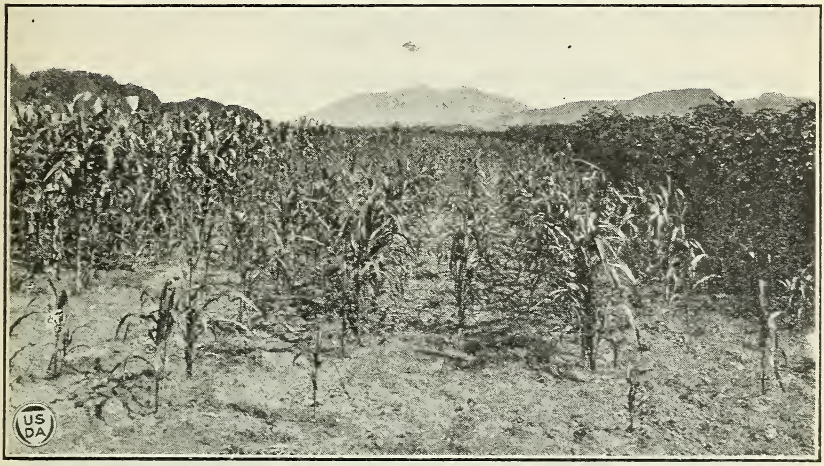

FIG. 7.—Field of Pima soft corn at the Cooperative Testing Station, Sacaton, Ariz., in 1921. A breeding block, largely composed of Laguna strains, is shown at the left.

In 1921 a test was made of several of the varieties of corn grown by Indians of different western reservations in comparison with the Sacaton June variety. The results are given in Table 8.

TABLE 8.—*Comparative yields of varieties of corn at the Cooperative Testing Station, Sacaton, Ariz., in 1921.*

Variety.	Source.	Yield per acre (bushels).
Pima	Gila River Reservation, Ariz	16.40
White Soft	Colorado River Reservation, Ariz	19.80
San Tan Yellow	Gila River Reservation, Ariz	30.00
Squaw corn	Rosebud Reservation, S. Dak	3.00
Hopi	Northern Arizona	6.60
He Dog	Rosebud Reservation, S. Dak	4.05
Sacaton June	Gila River Reservation, Ariz	52.00

In 1918 a test was made in order to compare the Sacaton June variety with a strain of Laguna grown near San Antonio, Tex., and with Chisholm, another popular Texas variety. The yields in bushels per acre were as follows: Sacaton June, 43.3; San Antonio Laguna, 38.3; Chisholm, 19.9.

An experiment was inaugurated in 1918, having as its object a comparison of the most approved method of ear-to-row corn breeding, with a method by which the variety is analyzed into approximately pure lines by self-pollination for a number of years, after which the most vigorous of these selfed strains are recombined.

It is still too soon for a definite comparison of the results of the two methods, but it is already apparent that for selfing to give the best results the foundation stock from which the original selections are made should be as large as practicable. The present experiment was started with 20 selected ears. After three years' selection it develops that all the promising lines have descended from a single original ear. It is obvious that if diversity of ancestry in the resulting variety is to be maintained, the foundation stock should have been much larger.

GRAIN SORGHUMS.

Several tests that have been made at the Cooperative Testing Station with grain sorghums, have demonstrated that these crops fit well into the agriculture as practiced under local conditions. Very satisfactory yields have been obtained at the station with many of the common varieties. A test conducted in 1921 for comparing standard yellow milo, dwarf yellow milo, and hegari gave yields of 59.7, 49.3, and 47 bushels per acre, respectively.

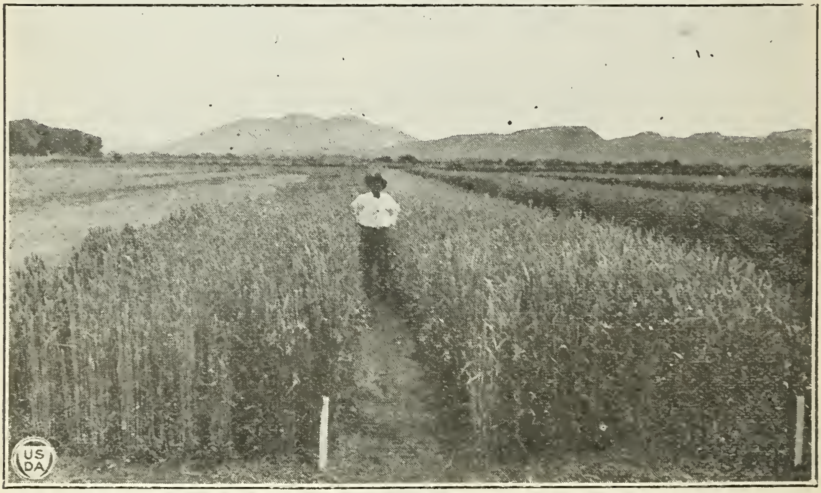

FIG. 8.—Wheat variety test at the Cooperative Testing Station, Sacaton, Ariz., in 1919. The Little Club variety is shown in the left foreground and the Dicklow at the right.

WHEAT.

Wheat is the most important crop grown by the Pima Indians on the Gila River Reservation, inasmuch as it usually can be grown successfully with the soil moisture from the winter rains, with perhaps one or two irrigations from river water at the time of winter or spring freshets. Through the influence of the station and the Indian Office district farmers, the Indians have in late years become familiar with the wheat varieties best adapted to their locality, and as a result more satisfactory yields are obtained. The principal varieties grown by the Indians are Baart (Early Baart), Sonora, and Little Club.

A variety test has been carried on at the station in cooperation with the Office of Cereal Investigations of the Bureau of Plant Industry since 1918. (Fig. 8.) The results of five years of tests with wheat varieties are given in Table 9.

TABLE 9.—*Comparative yields of wheat at the Cooperative Testing Station, Sacaton, Ariz., 1917 to 1921, inclusive.*

Class and variety.	Yield per acre (bushels).						
	1917	1918	1919	1920	1921	Average.	
						3 years, 1919 to 1921.	2 years, 1920 and 1921.
Common white:							
Baart (Early Baart)	36.60	44.50	45.30	....	53.50	....	....
Sonora	32.76	....	59.00	43.60	31.50	44.7	37.5
Dicklow	....	....	41.50	57.90	29.50	42.9	43.7
Pacific Bluestem	....	....	46.00	53.00	27.50	42.2	40.3
Hard Federation	....	....	....	53.30	31.00	....	42.1
White Federation	....	....	....	42.80	25.83	....	34.3
Hard red winter:							
Turkey	....	40.40	....	....	....	....	....
Kharkof	....	39.00	47.50	61.90	44.00	51.1	53.0
Kanred	....	37.30	....	....	....	....	....
Crimean	....	33.70	....	....	....	....	....
Alton (Ghirka Winter)	....	19.13	....	....	....	....	....
Soft red winter:							
Triplet	....	....	44.80	56.70	43.00	48.2	49.9
Hard red spring:							
Marquis	....	....	46.80	33.80	36.66	39.1	35.2
Club:							
Little Club	....	....	55.90	52.00	46.17	51.3	49.1

The Kharkof and Little Club varieties gave the highest average yields during the three-year period, 1919 to 1921, inclusive. The average yields of Baart (Early Baart) are not shown, because the yield of this wheat was not recorded in 1920. The Baart outyielded the Kharkof variety by an average of more than 4 bushels per acre during the three years in which both varieties were grown. The average yield of Baart in 1919 and 1921, when these two varieties were grown in comparative tests, is somewhat less than Little Club. With the exception of Little Club, Baart has given higher average yields than any other variety during comparable years. As Baart wheat is of considerably higher bread-making quality than Little Club, it is the more valuable variety.

WINTER RYE.

As a crop for adding organic matter to the soil, winter rye is one of the best winter crops for the river-bottom lands of the middle Gila Valley. In 1921 a planting at the Cooperative Testing Station produced more than 18 tons of green matter to the acre, or at the rate of 4.7 tons of dry matter per acre. The nitrogen content of the dry matter was 1.7 per cent.

ALFALFA.

The first experiment to be conducted at the Cooperative Testing Station upon its establishment was a variety test of alfalfa planted by Indian Office officials in cooperation with C. J. Brand, of the Bureau of Plant Industry, Department of Agriculture. Over 100 varieties from all parts of the world have been tested since that time, and repeated experiments have demonstrated the superiority of the Hairy Peruvian variety for hay production. This variety, which was introduced by the United States Department of Agriculture from Peru, has become recognized as best adapted to southwestern conditions. Hairy Peruvian, while not so hardy as some other varieties, does not become entirely dormant during the winter under Arizona conditions, and the growth made during the months when green feed is scarce makes it well adapted for the maintenance of a livestock industry. When conditions are favorable, Hairy Peruvian can be made profitable as an annual crop to grow in a rotation system with cotton, corn, grain, sorghum, etc., although it would be more desirable to have it grow two or three years to obtain the best results. The total yields of hay in tons per acre produced the first year at the Cooperative Testing Station by four varieties of alfalfa which were planted April 14, 1920, were as follows: Hairy Peruvian, 3.7; Smooth Peruvian, 3.1; India, 2.1; Arizona Common, 2.

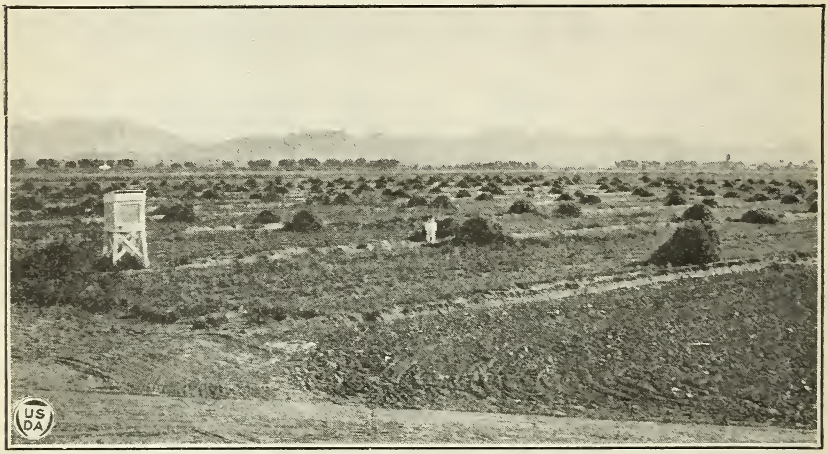

FIG. 9.—Alfalfa growing satisfactorily on virgin sandy soil at the seed farm, Sacaton, Ariz. Great difficulty is experienced in producing profitable yields of the common field crops on such soils until after alfalfa has been grown for some years.

Alfalfa has shown itself well adapted for the improvement of the sandy virgin soils of the foothills, as represented by the soil at the seed farm. (Fig. 9.) As a first-year crop on such soils, alfalfa succeeds when most other field crops fail. It has therefore been of inestimable value in making large areas of virgin soil in Arizona ready for general cultivation. Each year a certain part of the alfalfa acreage is used for seed production in order to be able to distribute seed to the Indians and to have a supply for further plantings in the rotation studies.

RHODES GRASS.

The first successful planting of Rhodes grass was made in 1921. Difficulties in obtaining good stands had been encountered in previous attempts. This trouble was experienced generally in the Salt River Valley, where many trial plantings were made in 1919 and 1920. Two methods of planting were followed in 1921. That prescribed by the seed dealers was to make use of a cotton planter which was so regulated that the seed would not be covered deeply and then irrigate frequently enough to keep the ground soft until the plants came up. The other method consisted in broadcasting the seed over a smoothly harrowed seed bed, covering by dragging a light float or harrow with teeth reversed over it, and then irrigating every third or fourth day until the plants showed above ground. The cotton-planter method resulted in complete failure, while a very satisfactory stand was obtained by the broadcast method. On account of the lateness of planting only two cuttings were secured, totaling 2⅕ tons per acre. This grass seems well adapted to growing on soils containing considerable quantities of alkali, such as is common on many of the Indian allotments along the Gila River. The plat on which the successful planting of Rhodes grass was secured was found to contain an average of 0.25 per cent total salts in the upper 4 feet of soil. Canada field peas failed to grow properly on this plat the previous fall on account of the accumulation of alkali.

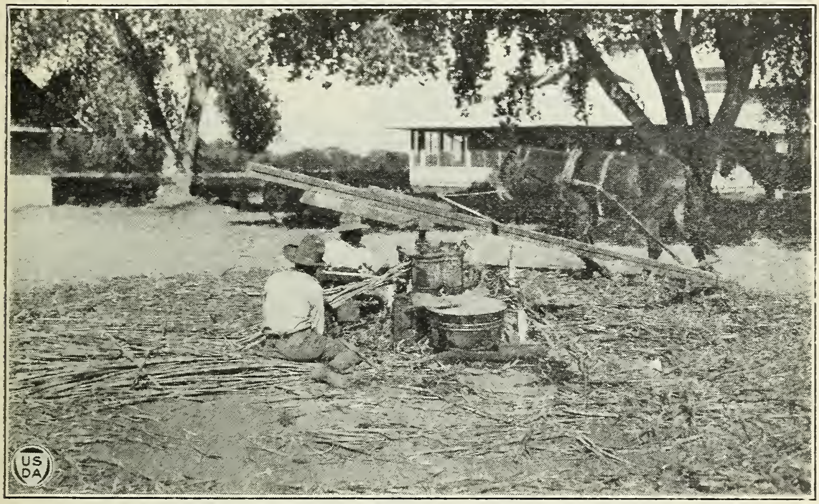

FIG. 10.—Pima Indians grinding sorghum for sirup making at the Cooperative Testing Station, Sacaton, Ariz.

FIELD PEAS.

The mild winters of the southern Arizona valleys are favorable for the growing of winter cover crops for soil-improvement purposes or for hay production. Canadian field peas and a variety produced largely in southern Colorado and known locally as "Colorado stock peas" are well adapted for the improvement of soils in the middle

Gila Valley. They are capable of producing large yields of vine during the winter months when the land would otherwise be idle, and this can be incorporated into the soil in time for the spring planting of other crops.

In the fall of 1920, 3 acres at the station were planted to Colorado stock peas, and by March 11, 1921, over 18 tons per acre of green material had been produced for plowing under preliminary to planting cotton. This quantity represented 2.3 tons of dry material, which on analysis showed a nitrogen content of 2.7 per cent.

Several variety tests have been conducted with peas during the past few years. The varieties which have been tested repeatedly are Blue Prussian, Golden Vine, Partridge, Blue Bell, Kaiser, Lima, Vida, Hubert, Chang, Bangalia, Nelson, and Colorado. The most promising for cover-crop purposes at Sacaton are Colorado, Golden Vine, Vida, Kaiser, Blue Prussian, and Chang.

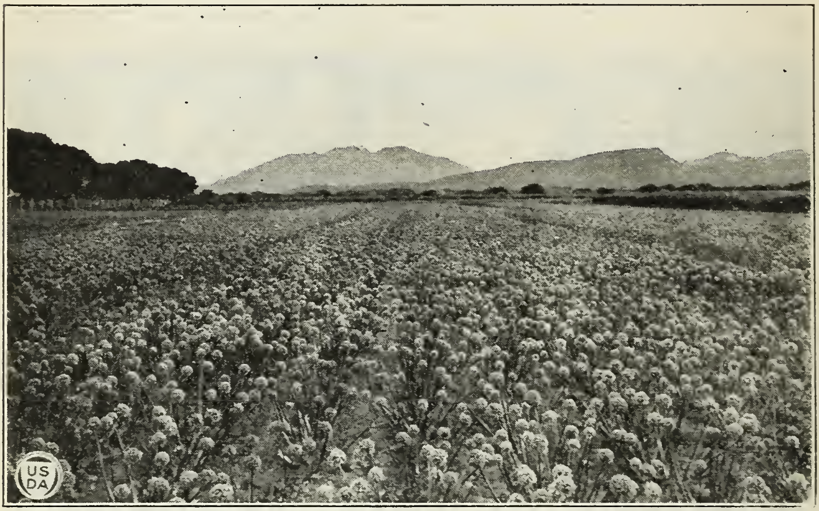

FIG. 11.—Field of Bermuda onions for seed production at the Cooperative Testing Station, Sacaton, Ariz., in 1919.

SWEET SORGHUM.

For several years tests have been carried on with sorghum varieties in order to ascertain those best adapted for the Indians to grow for sirup making and for soiling purposes. Yields of 10 to 18 tons of stripped cane to the acre have been obtained in some seasons. The Sumac, Gooseneck, and Honey varieties have proved well adapted for sirup making. Each year for four or five years the station has conducted demonstrations in sirup making for the Indians, and as a result many of them have learned to make sirup for home consumption. (Fig. 10.)

ONIONS.

By careful selection that has been continued since 1907 an improved strain of White Bermuda onions has been established, called Sacaton Bermuda. In 1915 there was produced at the station on one-eighth acre of ground 6,880 pounds of this improved variety, or at the rate of 27½ tons per acre. Almost every year the yields with this type of onion have been very satisfactory when planted on good soil. In 1920 the yield was at the rate of 12.9 tons per acre. Considerable interest has been taken by the Pima Indians in growing Sacaton Bermudas, especially for home consumption. Each year the station distributes many pounds of seed and several thousand seedlings from the seed bed in order to forward the development of this industry among the Indians. Other onion varieties that have proved successful at Sacaton are the Red Dongolia, Crystal Wax, Prizetaker, and Australian Brown.

ONION SEED.

Success was obtained in growing Bermuda onion seed early in the history of the station. Repeated tests proved the home-grown seed to be just as reliable as the imported seed. (Fig. 11.) The largest production of onion seed, 1,019 pounds per acre, was obtained in 1914. Yields as great as 600 pounds per acre have been obtained in subsequent years. It has been the custom to distribute to the Indians nearly all the onion seed produced at the station.

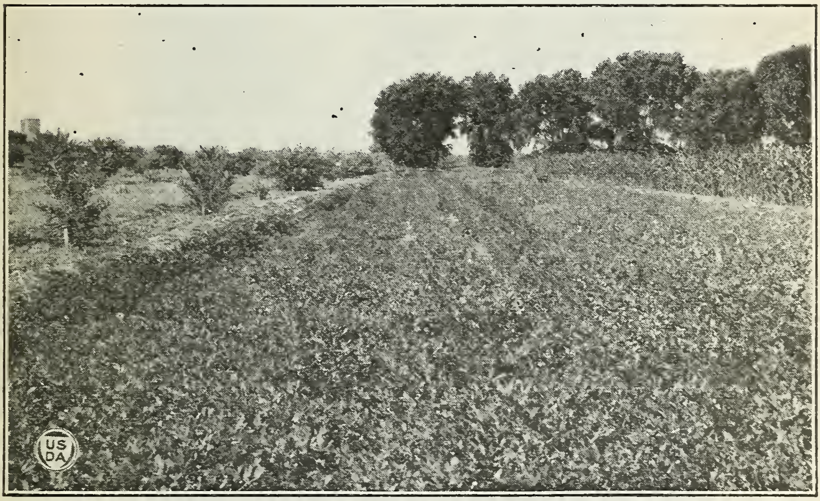

FIG. 12.—Field of peanuts at the Cooperative Testing Station, Sacaton, Ariz., in 1921. The three rows at the left are the Virginia Bunch variety. The three rows at the right are the Spanish variety.

SWEET POTATOES.

There are large areas of land in the Gila River Valley suitable for the production of sweet potatoes. A number of tests conducted at the cooperative testing station have shown that large yields can be produced on the fertile sandy soils along the Gila River.

Under the conditions existing in this valley deep plowing should not be practiced in preparing the ground for sweet potatoes, as a firm subsoil reduces the production of the undesirable long, stringy potatoes and causes the crop to develop nearer the surface, where they may be more easily harvested. In preparing the ground, ridges should be thrown up about 3½ feet apart and the plants set 12 to 15 inches apart on one side of the ridge. When the plants are well established the soil should be worked to them until by the time the runners have developed so as to prevent further cultivation the rows of plants are located in the centers of the ridges.

The varieties grown under the names White Vineless and Red Vineless have been found to be very satisfactory producers for local conditions. The Red Vineless yielded at the rate of 4 tons per acre in 1921 and Bradleys (probably Bradley "yam") at the rate of 4¼ tons. No other varieties were planted that season.

PEANUTS.

Two varieties of peanuts, Virginia Bunch and Spanish, were planted in 1921 on soil poorly adapted to most crop experiments because of its extremely sandy nature. (Fig. 12.) The Virginia Bunch yielded at the rate of 1,159 pounds per acre and the Spanish 852 pounds per acre. The Spanish peanuts, however, were better filled out and showed indications of being better adapted for the local conditions and for the poor soil on which they were grown. The growing of Spanish peanuts might well fill a place in Indian agriculture on the Gila reservation. The fact that this crop requires abundant irrigation water for only a brief period, its adaptability to sandy river-bottom soils, and the possibilities of marketing at the near-by cotton-oil mills gives it an advantage over many other short-season crops.

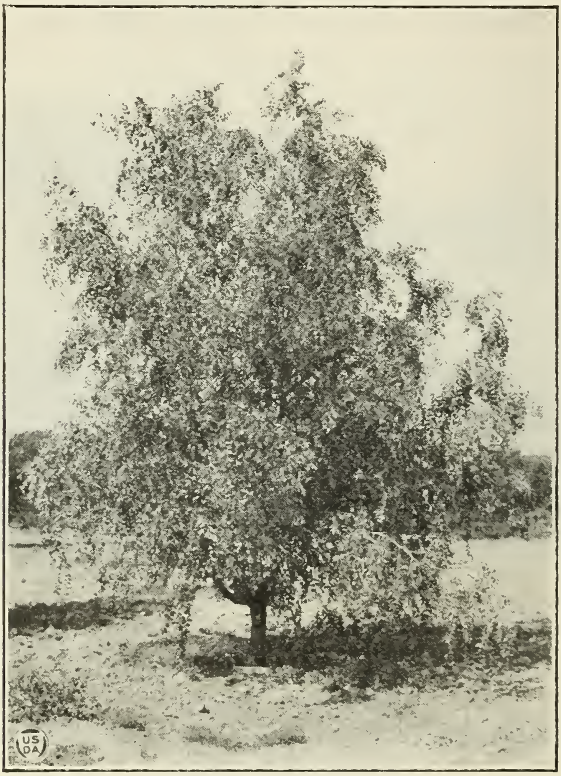

FIG. 13.—Jujube tree in bearing at the Cooperative Testing Station, Sacaton, Ariz., in 1921

FLAX.

Experiments were conducted during each of the years 1916, 1917, 1918, and 1919 with a number of flax varieties with view of ascertaining whether or not flax could be successfully grown for the production of seed under irrigation in Arizona. It was soon ascertained that only winter plantings gave any promise of success, and the yields from these were not sufficiently encouraging or consistent to warrant the conclusion that flax could be made a successful crop when grown in the irrigated valleys of the Southwest in competition with other crops. The yields obtained with flax varieties in 1916 and 1919 are given in Table 10.

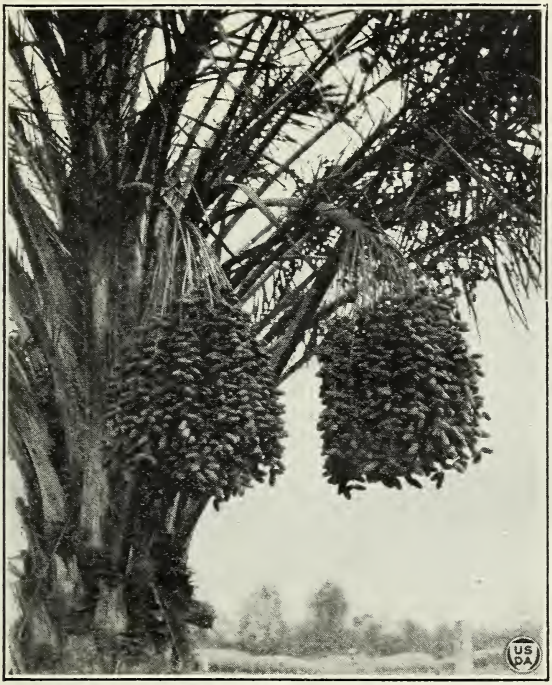

Fig. 14.—Clusters of Deglet Noor dates produced at the Cooperative Testing Station, Sacaton, Ariz., in 1921.

Table 10.—*Comparative yields of varieties of flax grown at Sacaton, Ariz., in 1916 and 1919.*

Variety.	C. I. No.	Yield per acre (bushels).	
		1916	1919
Damont	3	16.5	5.4
Golden	25	....	5.1
Smyrna	30	....	6.2
No. 27-5	149	....	10.0
Unnamed	151	....	11.0
North Dakota Resistant No. 114	13	11.5	....
Soddo	38	20.8	....
Unnamed	36	11.4	....

MELONS.

Each year since the station was established tests have been made to determine the best varieties of melons. Watermelons, muskmelons, Honeydew, and Casaba melons have been included in these tests. The indications are that Kleckley Sweet, Klondike, Black-Seeded Chilean, White-Seeded Chilean, Tom Watson, and Alabama Sweet watermelons are all adapted for general plantings. The Rocky Ford has proved to be the best type of muskmelon for Gila Valley conditions, but other varieties, including the Eden Gem and Extra Early Hackensack, are well adapted.

FRUIT CROPS.

The more common fruit crops, including peach, apricot, apple, pear, quince, and plums, do not appear to be well adapted to the silty river-bottom soils of the Gila Valley. Some of them, such as the peach, apricot, and pear, frequently bear heavily for a short time and then die. The root-rot disease without question is a serious obstacle to the growing of fruits in this area. Some of the pear varieties have been very successful at the cooperative testing station. Over a ton of fruit was harvested from 12 trees of the Bartlett variety in 1921. A planting of Winter Nelis pears has been bearing heavily for several years, but in late years the trees have begun to die rapidly.

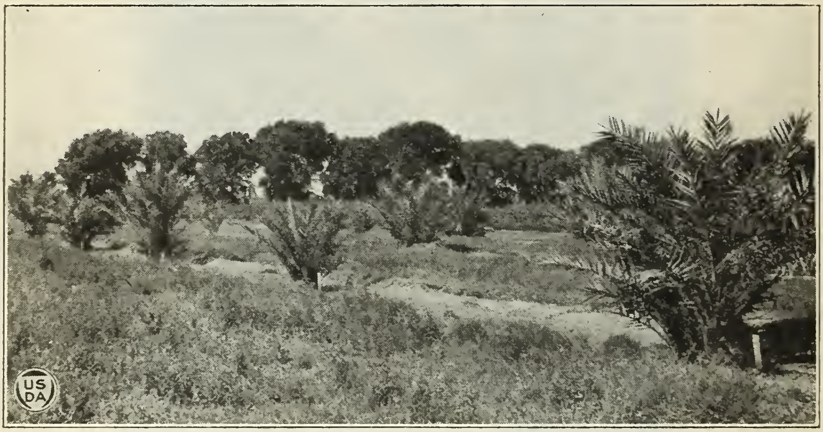

Fig. 15.—General view of the young date orchard at the Cooperative Testing Station, Sacaton, Ariz., in 1921. These trees, which are about 5 years old, were propagated from offshoots, and most of them bore fruit for the first time in 1921.

A number of other fruits have proved well adapted to the conditions which obtain at the station. Two or three varieties of jujubes are bearing heavily, and all of 30 or more trees planted during the past several years have survived. (Fig. 13.) The wild Chinese peach (*Amygdalus davidiana*), which was introduced for testing its possibilities as a disease and alkali resistant stock, did well for a number of years on soils with large accumulations of alkali. In late years the trees have failed to fruit and are dying rapidly.

DATES.[2]

There are at present growing at the Cooperative Testing Station 416 date palms, comprising 27 named varieties and 316 seedlings. Among the more important known varieties are the Deglet Noor, Saidy, Hayany, and Rhars. Five large trees of the Deglet Noor have been fruiting for several years. (Fig. 14.) This variety is not well adapted to the local climate, and as a consequence a large proportion of the fruit is annually lost. Part of the crop, however, reaches a stage where it may be picked and its ripening completed in an improvised oven with electric heat. One Rhars tree is bearing, but this variety is also subject to adverse climatic conditions and seldom matures a full crop. Among the younger trees which first came into bearing in 1921 (fig. 15) are represented the Rhars, Kustawy, Zehedy (fig. 16), Kalara, and Bayd Hammam varieties. The Hayany variety, of which there are 14 trees, and the Saidy, of which there are 13, have not yet fruited. Of the seedling trees 65 bore in 1921, showing a great variety of fruit. The greater proportion are of the characteristically inferior seedling sorts, but a few are rather promising, particularly from the standpoint of a dooryard tree for distribution among the Indians.

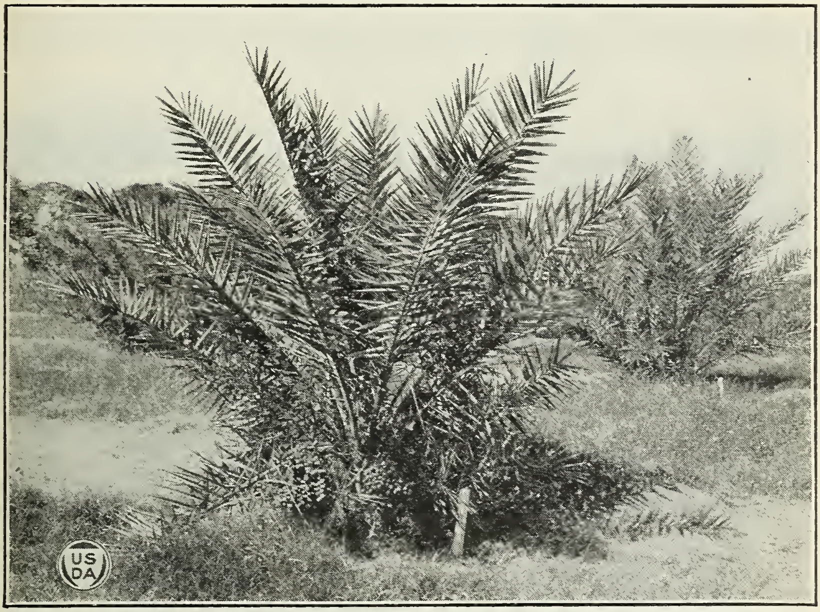

FIG. 16.—Zehedy date palm in bearing, propagated from an offshoot, at the Cooperative Testing Station, Sacaton, Ariz.

During the seasons of 1920 and 1921, 288 seedling trees, most of them females, were removed from the 6-year old plantings at the station and set out at regular orchard distances on contoured lines along the Little Gila River, a small stream which bisects the area between the Cooperative Testing Station and the Indian school campus. Practically 100 per cent of these have survived and are serving to beautify a heretofore unsightly landscape, besides possessing a potential value for fruit production in future years. A small number of offshoots have been transplanted to the home premises of Indians.

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[2] This part of the report was prepared by A. R. Leding, of the Office of Crop Physiology and Breeding Investigations, Bureau of Plant Industry.

GRAPES.

Over 60 varieties of grapes have been tested at the Cooperative Testing Station, and a number have proved well adapted. (Fig. 17.) The Sultana, the Sultanina, and the Malaga from Fresno especially have proved well suited as fresh grapes for Arizona conditions. Other varieties that bear regularly are the Muscat Albardiens, Cornichon, Dattier de Beyrouth, Golden Chasselas, and Malvasia. A large number of wine-grape varieties have also been tested for jelly making and grape-juice production. Zinfandel, Valdepenas, and Pagadebito are especially adapted for these purposes. Many cuttings and rooted plants of the successful grape varieties are distributed among the Indians each year, and several productive vineyards have resulted.

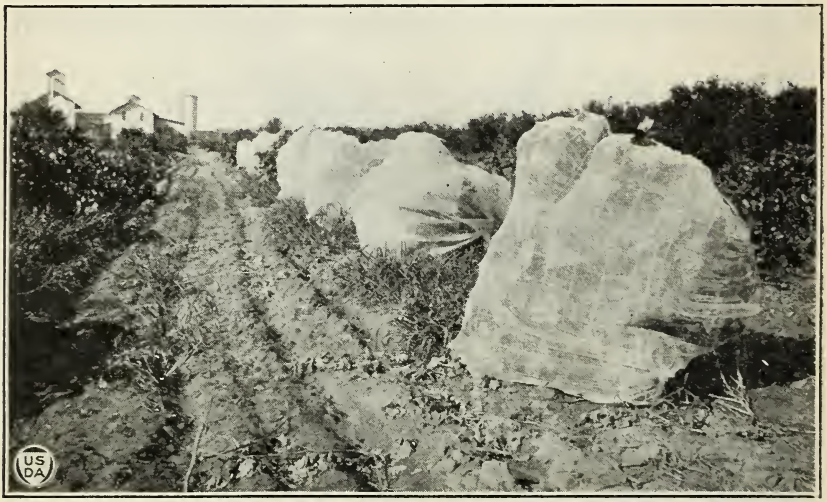
FIG. 17.—A planting of grape varieties at the Cooperative Testing Station, Sacaton, Ariz. The vines are covered with mosquito netting to protect the fruit from birds and insects and to delay ripening.

PECANS.

One of the most interesting experiments at Sacaton has been that conducted with pecans. The attempt to grow these trees here in 1908 was perhaps the first planting of pecans in Arizona. The fact has been established that under the conditions obtaining at Sacaton pecans can be grown with some measure of success under irrigation, and the plantings have been increased until at this time there are about 30 bearing trees, representing about 12 varieties. The varieties that have given the best results are the Alley (fig. 18), Delmas, Stuart, and Georgia (Georgia Giant). The last named yields heavily, but has not the eating quality nor the thin shell of the Alley, nor even of the Stuart and the Delmas. (Fig. 19.) The records of six trees for four years are presented in Table 11.

TABLE 11.—*Comparative yields of dried pecan nuts at the Cooperative Testing Station, Sacaton, Ariz., for the 4-year period from 1918 to 1921, inclusive.*

Field.	Row.	Tree.	Variety.	Yield per tree (pounds).			
				1918	1919	1920	1921
C-2	K	17	Georgia	12.63	19.25	20.06	29.50
C-2	K	16	.....do	5.56	2.63	6.13	.75
D-2	K	1	Alley	19.00	1.00	37.37	11.50
D-2	I	10	Delmas	3.00	....	16.75	.31
C-2	K	10	Kincaid	7.13	.44	15.75	3.00
C-2	K	11	.....do	6.75	.25	14.69	2.50

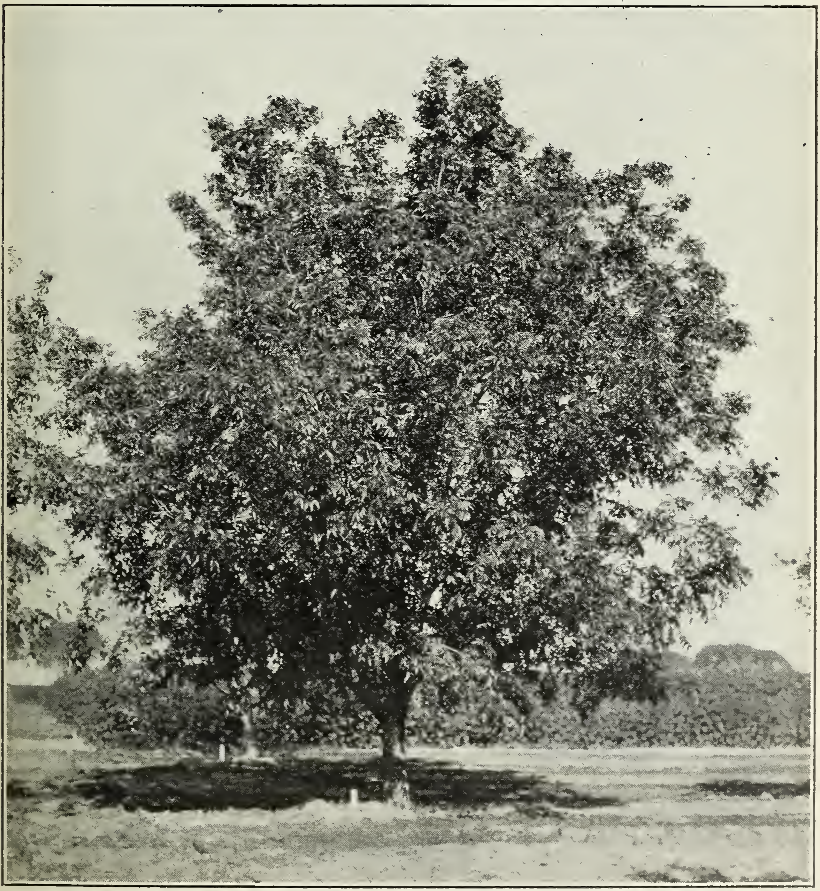

FIG. 18.—Pecan tree of the Alley variety, 12 years old, at the Cooperative Testing Station, Sacaton, Ariz., which produced 37 pounds of dried nuts in 1920 and 11½ pounds in 1921.

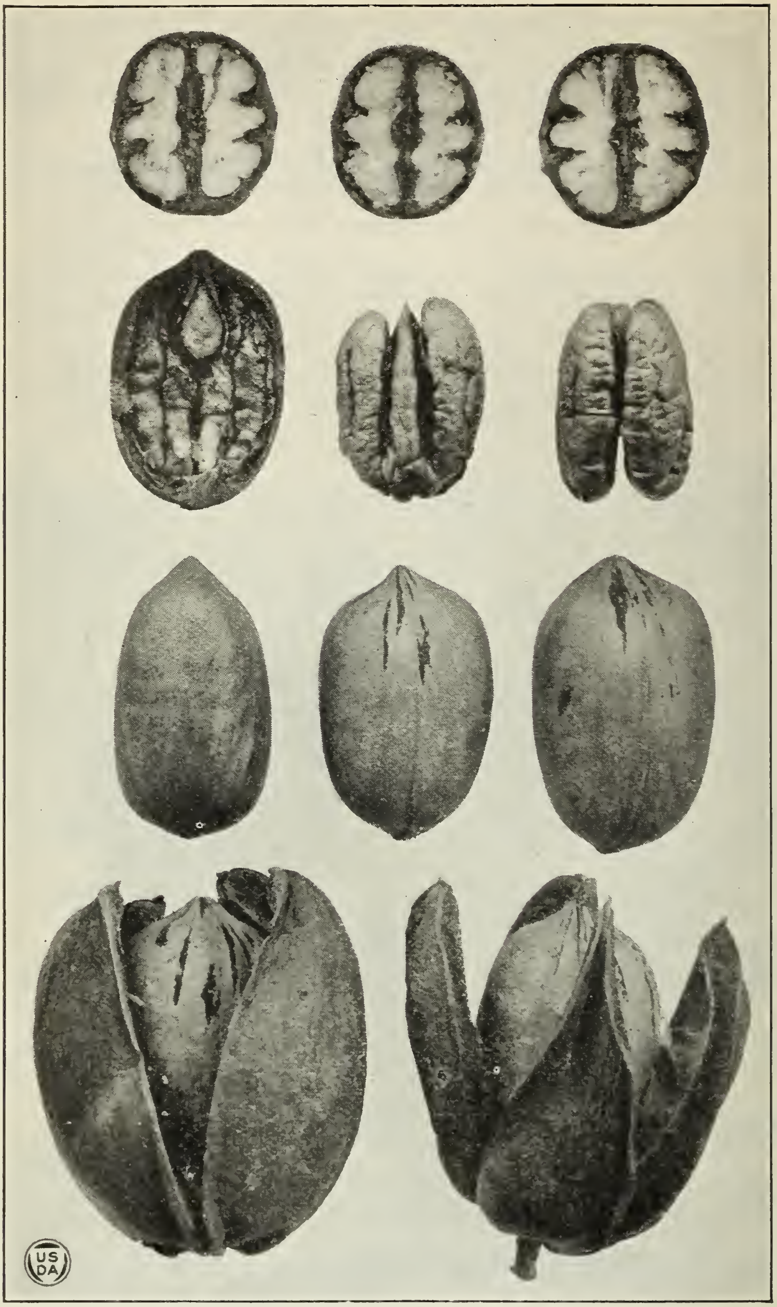

FIG. 19.—Specimens of Kincaid pecans produced at the Cooperative Testing Station, Sacaton, Ariz., in 1921. (Slightly reduced.)

POMEGRANATES.

There is no fruit crop grown at the Cooperative Testing Station which meets with greater interest from the Pima Indians than the pomegranate. The station, cooperating with the Office of Alkali and Drought Resistant Plant Investigations, has made a considerable study of pomegranate varieties with the view of ascertaining those best suited for plantings by the Indians. Over 30 named varieties have been tested since the first planting was made, and also many seedlings. There is probably no location in the Southwest where this fruit can be grown to greater perfection than in this vicinity. Fruits weighing as much as 2 pounds are quite common, and the

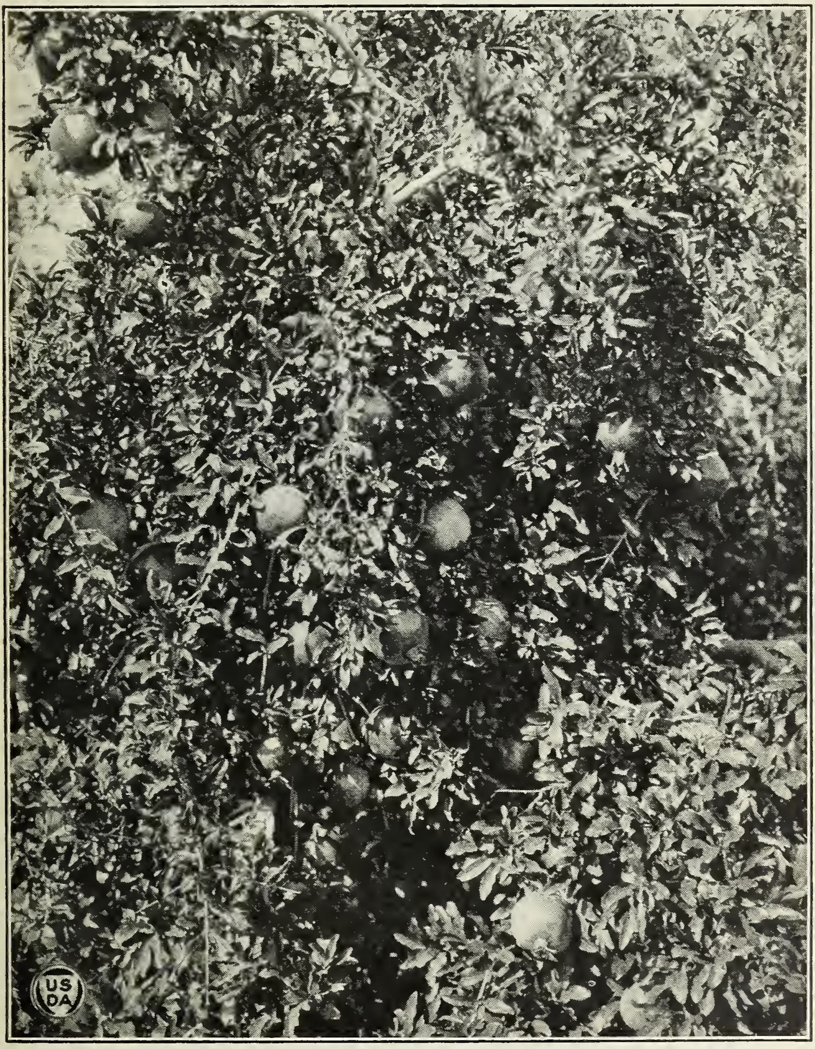

FIG. 20.—Red-fruited variety of pomegranates produced at the Cooperative Testing Station, Sacaton, Ariz., in 1921.

flavor of many of the varieties is delicious. Some of the varieties that are fruiting satisfactorily at the station at this time are the Bint el Basha, Black Arabian, Chelfi, Dessia, Jative, Greenrind, Hermosillo, Legrellei, Malissah, Mawardi, Papershell, Radiner, Red-Fruited (fig. 20), Red Sweet, Sin Pepitas, Suneiny, Spanish Ruby, Seify, Subacid, and Wonderful. Those that can be recommended for general planting are the Wonderful, Hermosillo, Greenrind, Jative, Spanish Ruby, and Sweet-Fruited.

Very little trouble has been experienced at Sacaton with the pomegranate disease organism (Sterigmatocystis), which is commonly reported as causing severe injury in other southwestern localities. The greatest damages sustained at Sacaton are from splitting and the injuries due to birds and June beetles.

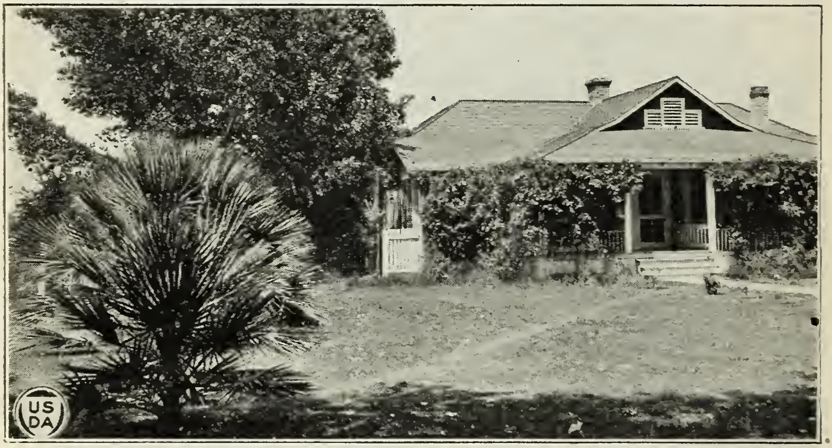

FIG. 21.—Climbing roses grown at the Cooperative Testing Station, Sacaton, Ariz., in 1919. Climbing Kaiserin Augusta Victoria at left; climbing Mademoiselle Cecile Brunner at right. An ornamental palm (*Washingtonia filifera*) is shown in the left foreground.

FLOWERS.

Over 50 varieties of roses have been planted at the Cooperative Testing Station for the purpose of securing varieties best adapted to the climatic conditions and to encourage the Indians to beautify their grounds. The results on the river-bottom soils near the station have been very discouraging with the greater number of varieties. Some, however, do well, among them the climbing Kaiserin Augusta Victoria and the climbing Mademoiselle Cecile Brunner. (Fig. 21.) The conditions at the seed farm are much more favorable for roses than those which obtain at the station.

ORNAMENTAL TREES AND SHRUBS.

Great possibilities are afforded for the growth of many types of ornamental plants in the valleys of southern Arizona. The Indians have been encouraged by the Cooperative Testing Station and by Indian Office officials to plant trees and shrubs for shade and ornamental purposes on their premises. There are several handsome specimens of ornamental palms on the Indian school campus and on the station grounds. (Fig. 22.) These are chiefly *Washingtonia filifera*, *Phoenix canariensis*, and the true date (*Phoenix dactylifera*). Special effort is now being made to secure several plantings of the so-called blue palm (*Glaucothea armata*),[3] which makes splendid growth in southern and Lower California and has done well in trial plantings in the Salt River Valley.

The mild temperatures of the winter make conditions very favorable for the successful planting of evergreens. The *Tamarix articulata* is especially adapted for hedges (fig. 23), windbreaks, and road borders, and the station distributes hundreds of cuttings each year to the Indian schools and to farmers of the adjacent valleys. The pepper tree (*Schinus molle*), Arizona cypress (*Cupressus arizonica*), Japanese privet (*Ligustrom japonicum*)), and Red gum (*Eucalyptus rostrata*) are some of the evergreen trees and shrubs that are being successfully grown at the station and on the Indian school campus. One of the most desirable evergreen ornamentals in this area is the olive tree, which is of additional value as a fruit bearer. Several hundred trees of the Chemlaly, Mission, and other varieties have been rooted at the station and transplanted to points of vantage on the Indian school campus.

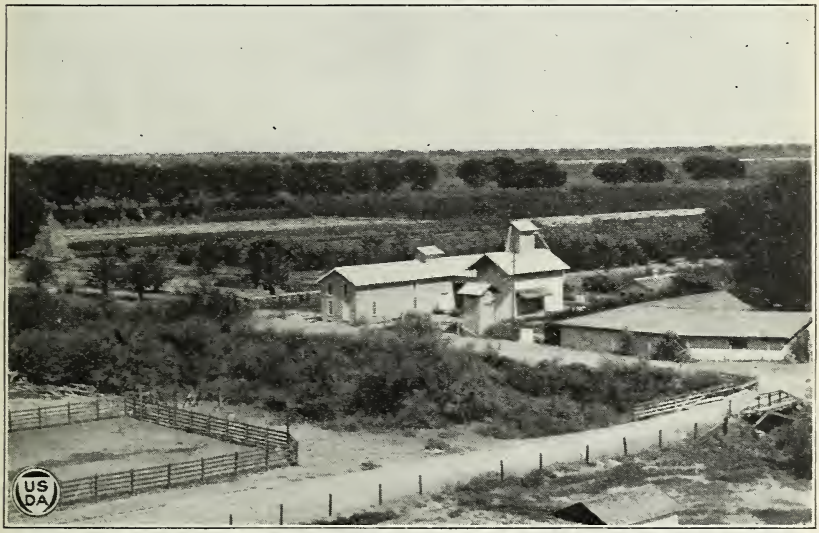

FIG. 22.—General view of the southwestern portion of the experimental grounds at the Cooperative Testing Station, Sacaton, Ariz., showing the ornamental character of the true dates (*Phoenix dactylifera*). A clump of native mesquite is shown in the near foreground and the Indian Office cotton gin in the center.

Of the deciduous trees, the following, which are indigenous in this area, can often be used to good advantage on the farms and public grounds: Cottonwood (*Populus mexicana*) (figs. 24 and 25), native willow (*Salix nigra vallicola*), mesquite (*Prosopis glandulosa*), and palo verde (*Parkinsonia torreyana*). All of these except the willow and cottonwood are transplanted with difficulty. The native ironwood (*Olneya tesota*) has been given particular attention, and at

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[3] Cook, O. F. Glaucothea, a new genus of palms from Lower California. *In* Jour. Wash. Acad. Sci., v. 5, p. 236–241. 1915.

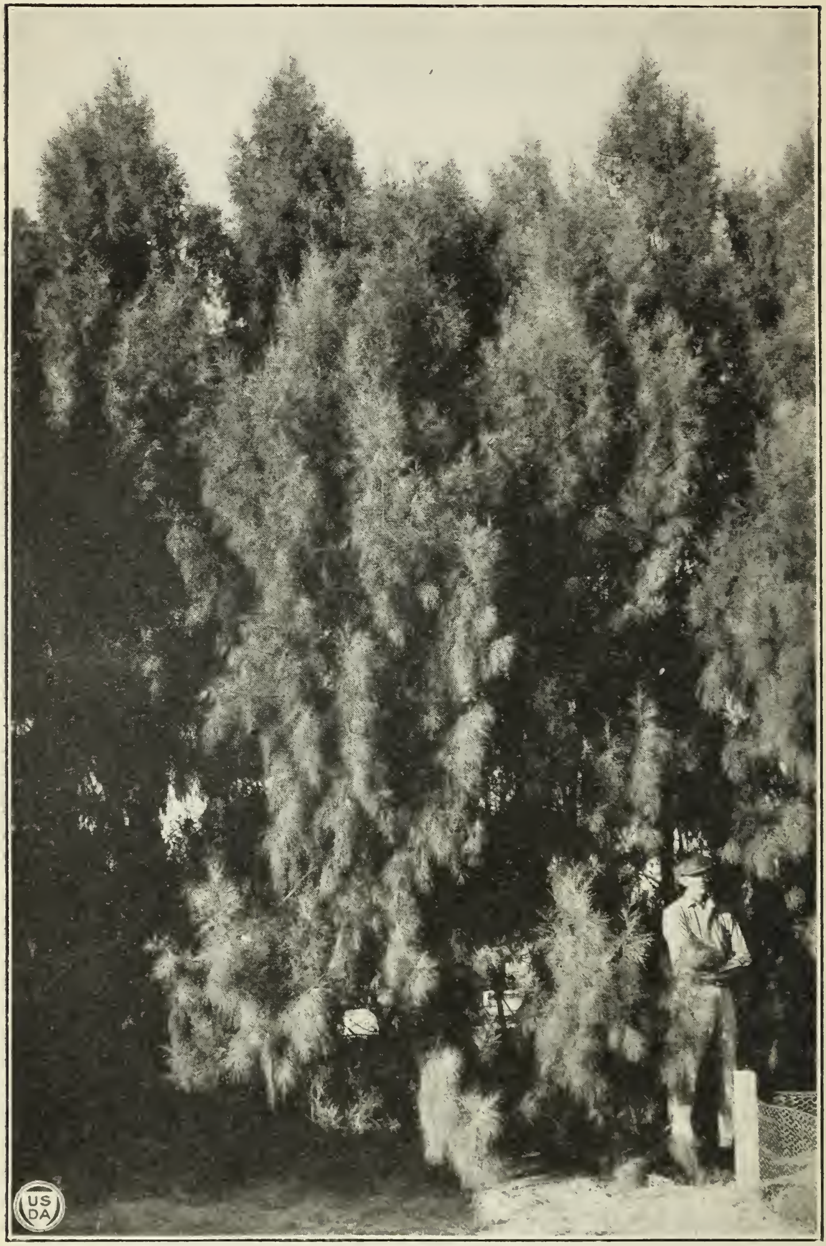

FIG. 23.—Group of tamarisks (*Tamarix articulata*) 2½ years old growing at the seed farm, Sacaton, Ariz., in 1921.

the station has been studied as to its possibilities for utilization as an ornamental, in hedge plantings, and for the production of beans. This tree, although of slow growth, makes a splendid ornamental when given the same care as other ornamental trees. Several splendid specimens of considerable age are located on the lawn in front of the superintendent's cottage at the seed farm and set off the grounds to excellent advantage. (Fig. 26.) This tree transplants with difficulty and should be started from seed in pots or planted directly.

Other trees that are valuable for shade purposes are: Texas umbrella tree (*Melia azedarach umbraculifera*), Dwarf elm (*Ulmus pumila*), hemp tree (*Vitex negundo*), Carolina poplar (*Populus eugenei*), Arizona ash (*Fraxinus velutina*), pomegranate (*Punica granatum*), and Jerusalem thorn (*Parkinsonia aculeata*).

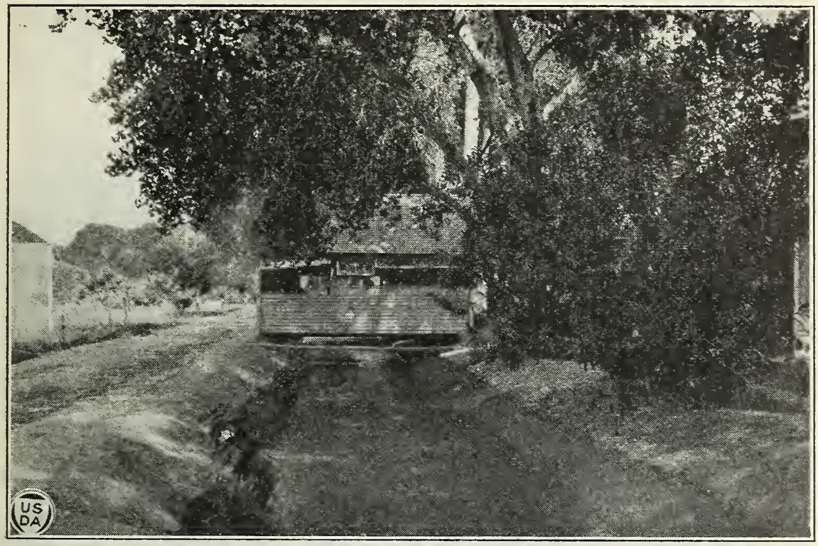

Fig. 24.—Oleander (*Nerium oleander*) and *Populus mexicana* at the Cooperative Testing Station, Sacaton, Ariz., showing their shade and ornamental character. The sleeping quarters of employees are shown over the irrigation ditch and at the extreme right.

The pistache tree is a very desirable shade tree in addition to its value for producing nuts. A row of 22 of these trees (*Pistacia vera*) were set out at the station about 1910 for testing its possibilities as a stock on which to graft the less hardy commercial varieties. No grafting was done on these trees and they have grown into very handsome ornamentals with very desirable shade value. (Fig. 27.)

EXPERIMENTS IN COTTON ROOT-ROT CONTROL.

In 1920 experiments were started to determine the effect of certain chemical and cultural treatments on the prevention of root-rot in cotton. In order to test the effect of thorough aeration of the infected soil, three excavations were made in plat C2–17, the soil being removed from areas about 10 by 26 feet by 4 feet deep. The loose soil was exposed to the elements for about two weeks, was then scraped back into the excavations, and the land was leveled and planted. The disease proved as active in the excavated areas as in other portions of the field.

Plat C2–19 in 1920 was flooded about 13 times previous to planting in order to determine the effect of abundant soil water on the root-rot organism. The disease did not appear to be affected by this treatment.

In 1920 a section of plat C2–23, which had shown a severe infection in the previous crop of cotton, was severely blasted with 40 per cent dynamite. The charges were placed 7 by 7 feet apart and to a depth of 4 feet, two sticks being used for a single charge. This method of disrupting and aerating the lower soil layers apparently had no effect on the further activity of the organism.

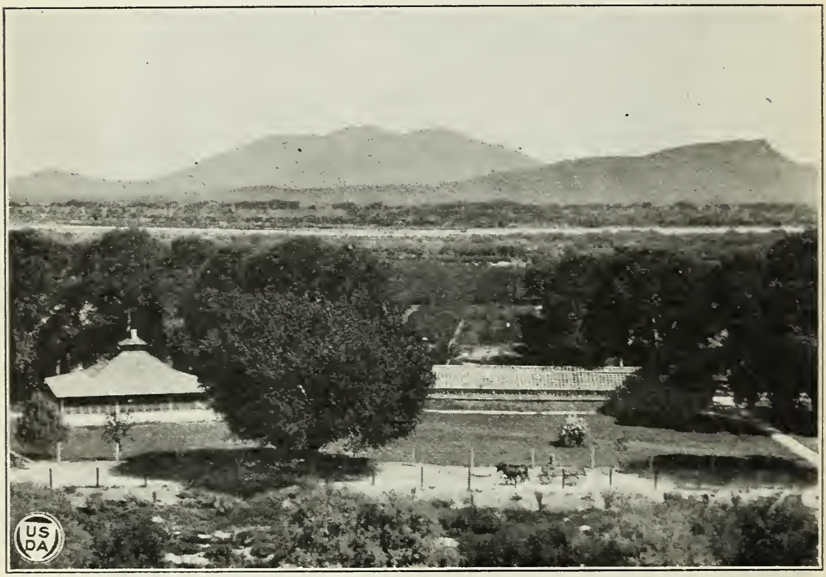

FIG. 25.—Cottonwood trees (*Populus mexicana*) at the Cooperative Testing Station, Sacaton, Ariz., in 1921, showing their value for shade.

Plat C2–21 was given a treatment of sulphuric acid with irrigation water in both 1920 and 1921. In 1920 the acid was applied at the rate of 2,000 pounds per acre, 1,000 pounds per acre being applied on July 8 and a like quantity on July 13. The appearance of the disease on this plat seemed to be somewhat belated and it was believed wise to continue the treatment in 1921. An application at the rate of 5 tons per acre was made previous to planting, and another at the rate of 2½ tons just previous to the time the attack was expected. There was a decrease of 33.1 per cent in the number of plants which died of the disease as compared with the previous season, but in following the behavior of root-rot from season to season under any conditions it is found that such differences are not necessarily significant.

Lister planting.—It having been noted that cotton in the rows closest to the irrigation borders appeared to be less affected by the root-rot, in 1921 plat C2–17 was furrowed out with a lister, ridges were thrown up between the furrows with a border disk, and the seed planted in the bottom of the furrows. No beneficial results came from this treatment.

Manure treatment.—After the cotton was harvested in 1920 plat C2–19 was furrowed out with a lister and by hand shoveling until deep wide furrows or ditches were prepared the same distance apart as the previous cotton rows. These were filled with barnyard manure and green alfalfa, covered by disking, leveled, and allowed to remain until planting time in the spring. The seed were then planted directly over the organic material. There was a decrease of 57.9 per cent of dead plants as compared with the previous year, but conclusions are not warranted from one year's behavior in dealing with this disease.

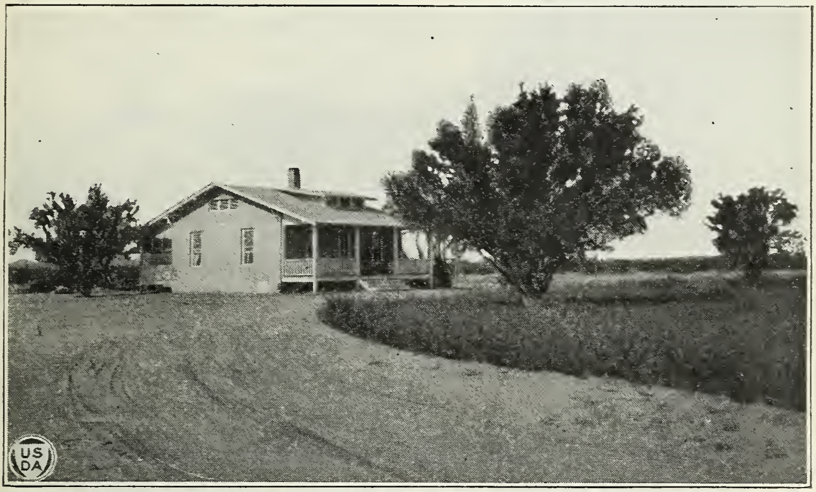

FIG. 26.—Native ironwood (*Olneya tesota*) at the seed farm, Sacaton, Ariz., showing its ornamenta character.

In addition to testing methods of control, considerable study has been made of a fungus associated with root-rot. Pathologists have not definitely determined a fruiting stage of the root-rot organism, except Duggar, who in 1915 made collections and studied material which he found associated with root-rot and described the conidial stage. Material such as described by Duggar was found at Sacaton and vicinity in great abundance immediately following two prolonged periods of rainy weather in August and September, 1921. In alfalfa fields infected with root-rot the conidial mats almost invariably appeared in circles in close proximity to the circle of recently dead alfalfa plants.

CROP EXPERIMENTS AND SOIL IMPROVEMENT AT THE SEED FARM.[4]

The seed farm, which had its inception in 1917, has for its purpose the supply and maintenance of stocks of pure seed for the use of the

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[4] This part of the report was prepared by A. R. Leding, superintendent of the seed farm.

Indians on the reservation. Problems arising in connection with the cultivation and fertilization of the sandy mesa soil, which is very low in organic fertility and representative of thousands of acres in the middle Gila or Casa Grande Valley, are being studied, and various field crops and fruits are being tested.

Since the beginning of the work the main problem has been to increase the fertility of the soil to a point where cotton, corn, and other field crops can be made to yield an adequate return. The growing of Hairy Peruvian alfalfa has been the principal means for attaining this end, and the results obtained have been satisfactory to a high degree. (Fig. 7.)

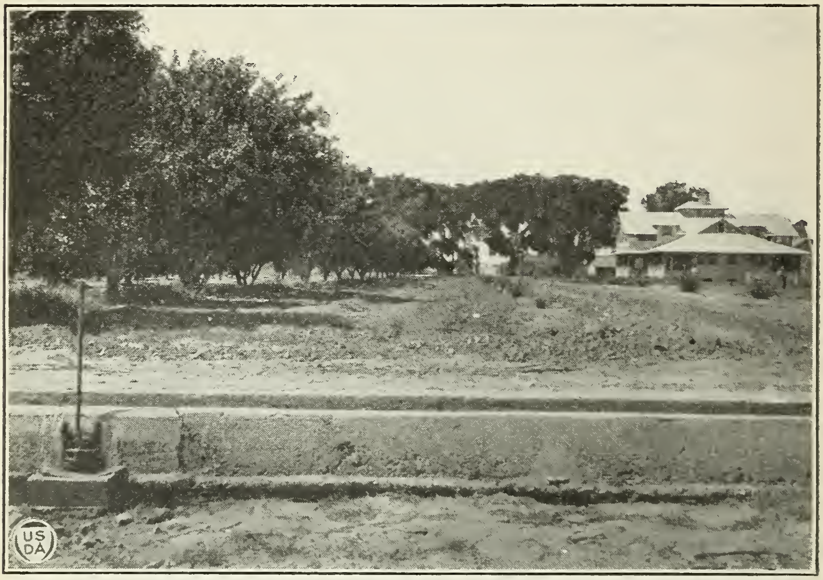

FIG. 27.—Rows of pistache trees (*Pistachio vera*) at the left, showing their excellent shade and ornamental character. The office building is at the right.

Only one variety of each crop has been planted on the seed farm in a single season, selecting such varieties as Pima Egyptian cotton, Sacaton June corn, and Hairy Peruvian alfalfa, in order that these strains may be kept pure and free from mixture by cross-fertilization.

The improvement in the growth and yields of Pima cotton since it was first planted has been very marked. Planted the first year (1918) on virgin soil, the plants made a very poor growth with short whiplike center stalks and few branches, either vegetative or fruiting. A yield averaging 585 pounds of seed cotton or slightly more than a quarter of a bale per acre was produced.

In 1919, 11.2 acres of cotton were grown, of which 3.3 acres was on land previously in grains. A little over an acre of this land had had the grain straw spread thickly over it and turned under, while the remainder received an application of barnyard manure at the rate of about 20 tons per acre on top of the grain stubble. There were also 2.8 acres previously planted to white sweet clover which failed to make a stand that received an application of manure at a rate of about 18 tons per acre. The remainder of the cotton acreage was in small tracts previously planted to cotton, alfalfa, clover, and Sudan grass, with 1.8 acres in new land not previously cultivated. Six-tenths of an acre was ratooned and gave an increase over the year before of 567 pounds per acre, the yield on this tract being 885 pounds per acre, or nearly half a bale. The total cotton acreage yielded on the average 763 pounds of seed cotton per acre. Leaving out the new land, the average production on the remainder was 818 pounds per acre. The virgin soil produced 281 pounds per acre. The yield on the land previously cropped or fertilized, compared with that on the new land of the year before, shows an average increase of 131 pounds of seed cotton per acre, while a comparison with the new land of the same year shows an increase of 537 pounds per acre. The following year the 3.3 acres which had grown a grain crop and received the manure application was given 3 additional tons of manure per acre. The area produced 946 pounds of seed cotton per acre compared with 796 pounds the year before. An application at the rate of 8 tons of manure per acre was made to the 1.8 acres of new land, which then produced 355 pounds per acre in comparison with 281 pounds the previous year. Another tract of a third acre was ratooned this year and gave a total yield of 2,567 pounds of seed cotton per acre, an increase of 1,627 pounds per acre. The average production per acre for the year on the 9.1 acres planted was 779 pounds of seed cotton.

In 1921 the cotton production was shifted to another section of the farm which had been in alfalfa for two or three years. The production of seed cotton per acre was as follows: Two-year alfalfa land, 1,282 pounds; 2½-year alfalfa land, 1,497 pounds; and 3-year alfalfa land, 1,269 pounds. The apparently reduced yield on the 3-year alfalfa land was due in part to the less perfect stand of the plants which was secured on this area. On about 2½ acres of the 3-year alfalfa land a fertilizer experiment was carried on, nitrate of soda, acid phosphate, potash, cottonseed meal, barnyard manure, and 9–3–1 commercial fertilizer being used in various proportions. No positive effects could be observed as resulting from these applications. A half acre of new land was also planted to cotton and gave a yield of 756 pounds per acre as against 1,329 pounds, the average for the alfalfa land.

WORK CONDUCTED AT SACATON BY THE OFFICE OF ALKALI AND DROUGHT RESISTANT PLANT INVESTIGATIONS.[5]

Breeding work with the Egyptian type of cotton has been carried on since 1908, i. e., during all but the first year since the establishment of the Cooperative Testing Station. The outstanding result has been the development of the Pima variety, which originated with a plant discovered by T. H. Kearney in a field of Yuma cotton grown at the station in 1910. Selection has been carried on during each succeeding year in order to maintain uniform strains of the variety and, if possible, to improve it. Recently a special endeavor has been made to develop a smoother seeded strain of Pima cotton, and the results appear to be promising. The Pima progenies have been located on the seed farm during the last two seasons with a view to avoid as far as possible contamination by cross-pollination with other varieties of cotton grown experimentally at the station.

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[5] This part of the report was prepared by T. H. Kearney, physiologist in charge of the Office of Alkali and Drought Resistant Plant Investigations, Bureau of Plant Industry, who had supervision of the work.

Breeding work is also being carried on with the Yuma and Sakellaridis varieties, and the possibility of developing a superior cotton by the hybridization of Pima with Sakellaridis and with sea-island cotton is receiving attention.

Genetic investigations have been carried out with hybrids between different varieties of the Egyptian type and with hybrids between Egyptian and upland cottons. This work, while mainly of scientific interest, has a practical bearing in throwing light upon the nature and extent of the segregation occurring when different varieties or types of cotton become hybridized accidentally. It is believed that the results will prove useful in helping to explain the origin of off-type plants encountered in roguing seed-increase fields.

Extensive investigations of self-fertilization and cross-fertilization in the Egyptian type of cotton have been made during the past five years, and the results are ready for publication.

The alkali resistance of Egyptian cotton has been the subject of considerable study at Sacaton. In the summers of 1920 and 1921 Dr. J. Arthur Harris, with several assistants, conducted extensive investigations of the osmotic pressure and other properties of the cell sap of Egyptian and upland cottons with a view to determining whether any correlation exists between the cell-sap properties and the relative alkali resistance of these very distinct types. The results of this investigation are in preparation for publication by Doctor Harris.

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